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Be a Better You

Smart, Happy, Relaxed

HOW TO:
STOP NEGATIVE THINKING IN ITS TRACKS

GET AHEAD AT WORK

STRENGTHEN YOUR RELATIONSHIPS

FIND JOY IN YOUR LIFE

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EDITOR IN CHIEF
AND SENIOR VICE PRESIDENT
Mariette DiChristina

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FROM THE EDITOR

The Way to Well-Being

EVERY NEW YEAR MILLIONS OF PEOPLE VOW TO FINALLY GET IT TOGETHER and improve themselves—from health factors, to relationships, to overall happiness in life. Yet statistics show that fewer than half of them will have stuck to their resolutions even six months later. Are humans so weak-willed? Or are our tactics of self-improvement flawed?

To be sure, self-improvement requires effort and discipline, and the latest diet and lifestyle crazes are often cocktails of unsubstantiated claims and promises. Yet science has identified a variety of methods that can help us to live better lives. In this special issue, we explain what the latest research has discovered about attaining professional success, finding contentment in life, and increasing physical and emotional wellness.

Considering that five days a week most of us spend more than 50 percent of our waking hours at work, the occupational environment can be a great place to start. Beat stress using a 10-pronged approach that includes building a support network and reinterpreting negative events (*page 4*). Cultivate creative thinking by breaking your normal routines and habits (*page 14*). Also, increase your overall performance by completely disconnecting from work on a regular basis (*page 22*).

At work and beyond, learning to control your emotions can lead to a calmer, more balanced existence (*page 42*). On the home front, focusing on positive experiences with your partner can enhance the joy in your relationship (*page 62*). To boost your mood, try out a 10- to 15-minute meditation to improve your focus and attention (*page 54*). And if you need a creative spark, try opening your mind by engaging in novel pursuits. You will look at the world in a whole new light (*page 68*).

One of the simplest ways to power up? Get moving! Beyond burning calories, consistent cardio and weight routines charge the immune, endocrine and neurological systems (*page 78*). In fact, a large health trial recently reported that regular workouts can stave off dementia, even in people older than 60 (*page 106*). In addition to exercising, don't forget to eat well: the right diet is good for both body and mind (*page 98*).

Finally, whatever the year brings, remember to take it easy. Mounting evidence is showing that adopting a policy of self-compassion reduces stress and bolsters resilience (*page 48*), whether or not you achieve your goals. So give yourself a break and handle your own heart with care. It might be the ticket to happier living. SA

Andrea Gawrylewski
Collections Editor
editors@sciam.com

BE A BETTER YOU

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SCIENTIFIC AMERICAN MIND

BEHAVIOR • BRAIN SCIENCE • INSIGHTS

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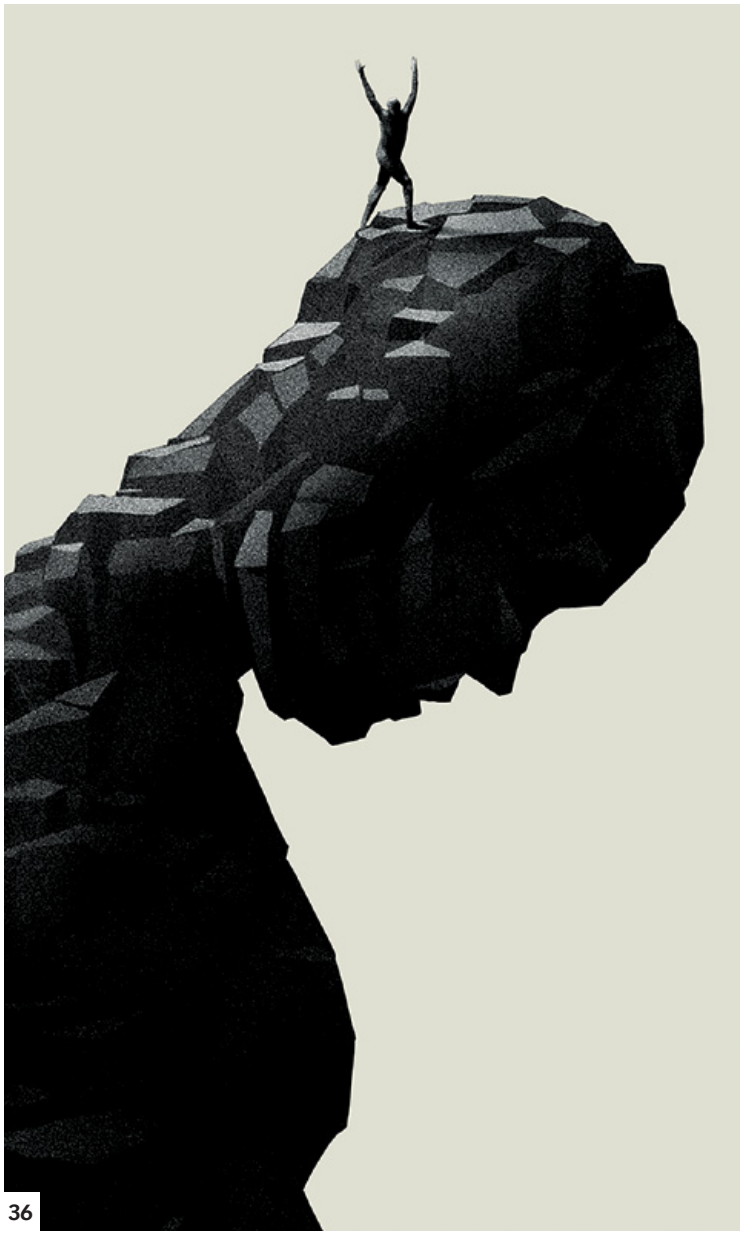
Be a Better You:
Smart, Happy, Relaxed



36

HOW TO SUCCEED AT WORK

4 Ready for Anything
Scientists have compiled evidence-based tactics for building resilience. Among them: rethink adversity, forge close friendships and tackle novel challenges.
By Steven M. Southwick and Dennis S. Charney

14 Your Fertile Brain at Work
Scientists have mapped the innovative mind so that we can remake our own in its image.
By Evangelia G. Chrysikou

22 Give Me a Break
A wealth of psychological research shows that mental downtime is vital for productivity and health. Some progressive companies are finally starting to listen.
By Ferris Jabr

28 The Power of Reflection
Insight into our own thoughts—or metacognition—is key to high achievement in all domains.
By Stephen M. Fleming

36 Conquer Yourself, Conquer the World
Self-control is not just a puritanical virtue. It is a critical psychological trait that breeds success at work and play—and in overcoming life's hardships.
By Roy F. Baumeister

THE PURSUIT OF HAPPINESS

42 How to Control Your Feelings—And Live Happily Ever After
Learning to regulate powerful emotions can enhance physical and mental well-being.
By Steve Ayan

48 The Self-Compassion Solution
Building on a Buddhist principle, psychologists are learning how being kind to yourself can bolster resilience, buffer against stress and improve relationships.
By Marina Krakovsky

54 Being in the Now
A focus on the present, dubbed "mindfulness," can make you happier and healthier. Training to deepen your immersion in the moment works by improving attention.
By Amishi P. Jha

62 The Happy Couple
The key to keeping the magic alive in a marriage, experts say, is finding ways to promote the positive.
By Suzann Pileggi Pawelski

68 Openness to Experience: The Gates of the Mind
People who are "open to experience" literally see the world differently.
By Luke D. Smillie

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48

84

72 The Joyful Mind
A new understanding of how the brain generates pleasure could lead to better treatment of addiction and depression—and even to a new science of happiness.
By Morten L. Kringelbach and Kent C. Berridge

HEALTHY BODY, HEALTHY MIND

78 Why Exercise Works Magic
Being active is good for us for many reasons beyond the old familiar ones.
By Shari S. Bassuk, Timothy S. Church and JoAnn E. Manson

84 Sleep on It!
Your nightly rest turns out to affect your mind and health more than anyone suspected.
By Robert Stickgold

90 Mind of the Meditator
Contemplative practices that extend back thousands of years show a multitude of benefits for both body and mind.
By Matthieu Ricard, Antoine Lutz and Richard J. Davidson

98 In Search of the Optimal Brain Diet
The field of nutritional psychiatry is taking off as scientists home in on the ingredients for good mental health and cognitive staying power. *By Bret Stetka*

106 A Rare Success against Alzheimer's
A gold-standard trial provides evidence that diet, exercise and an active social life can help prevent cognitive decline.
By Miia Kivipelto and Krister Håkansson

DEPARTMENTS

1 FROM THE EDITOR
The Way to Well-Being

112 END NOTE
A Smart Schedule for Contentment
By Tori Rodriguez

BE A BETTER YOU

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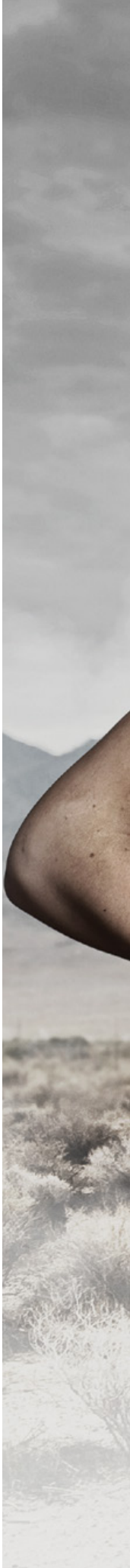
HOW TO SUCCEED AT WORK

READY FOR ANYTHING

Scientists have compiled evidence-based tactics for building resilience. Among them: rethink adversity, forge close friendships and tackle novel challenges

By Steven M. Southwick and Dennis S. Charney



IN BRIEF

Resilience is the ability to modulate and constructively harness the stress response—a capacity essential to both physical and mental health.

Success can hinge on resilience. Setbacks are part of any endeavor, and those who react to them productively will make the most progress.

A person can boost his or her resilience. Strategies include reinterpreting negative events, enhancing positive emotions, becoming physically fit, accepting challenges, maintaining a close social network and imitating resilient role models.

Photo Illustration by Aaron Goodman

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AS A COLLEGE STUDENT AT BROWN UNIVERSITY, JERRY WHITE SPENT his junior year abroad studying in Israel. On a sunny day during the Passover holiday in April 1984, White and two friends set out for a camping trip in the Golan Heights. "I was walking out ahead of my friends with a song in my heart. I like being the leader, the one out in front," he recalls. "Then, boom! A huge explosion." He had stepped on a land mine. As blood poured from his leg, White screamed, "I have no foot! I have no foot!" White's friends wrapped his stump with a shirt, tied a makeshift tourniquet around the injured leg and carried him through what they now knew was a minefield. For the next four months White lived in two Israeli hospitals where he felt helpless, sad and alone. "People were trying to introduce themselves, but they were all missing arms, legs, eyes, or they were burn victims. I felt sick and afraid," he says.

Eventually White returned home, completed college and worked as a substitute teacher before becoming an activist working on behalf of fellow victims. In 1995 he, along with his friend and colleague Ken Rutherford, who had lost both legs to a land mine in Somalia, founded the Landmine Survivors Network (renamed Survivor Corps). This group played a leading role in the International Campaign to Ban Landmines, which was awarded the Nobel Peace Prize in 1997.

White's transformation from frightened victim to passionate survivor demonstrates resilience, the "process of adapting well in the face of adversity, trauma, tragedy, threats or even significant sources of stress," according to the American Psychological Association. A resilient person may bend but does not break when confronted with adversity, enabling him or her to bounce back relatively quickly.

Biologically, resilience is the ability to modulate and constructively harness the stress response—a capacity essential to both physical and mental health. Un-

KAREN BALLARD *Redux Pictures*

WARTIME INJURIES need not be devastating. Many veterans learn and grow from their traumatic experiences.

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RESILIENCE is critical to success. The ability to keep working toward a goal in the face of difficulty separates the CEOs from the pack.

checked, chronic stress can impair the immune system and contribute to illnesses such as gastric ulcers, asthma, depression, diabetes and heart disease. Stress can also spawn unhealthy behaviors such as smoking and excessive alcohol use.

Success appears to hinge on resilience. Setbacks are part of any human endeavor, and those who react to them productively will make the most progress. In a 2002 *Harvard Business Review* article, Dean M. Becker, who is a founder of the resilience-training company Adaptiv Learning Systems, is quoted as saying, "More than education, more than experience, more than training, a person's level of resilience will determine who succeeds and who fails. That is true in the cancer ward, it is true in the Olympics, and it is true in the boardroom."

Whether a person hangs tough or gives up in hard times depends on influences at multiple levels, from molecules to neighborhoods. Resilience is determined by both inborn traits and environmental factors that affect the capacity to adapt to stress. Although some of these environmental influences, such as poverty, are difficult to alter, a person can increase his or her level of resilience by developing mental and physical habits that foster positive adaptation to stress and trauma.

STANDING UP TO STRESS

BROWSE THROUGH the magazine section of any bookstore or drugstore, and you will find an assortment of articles on how to reduce stress: "7 Rules for a Stress Free Life," "Leave Your Stress Behind," "How You Can Reduce Your Stress and Your

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Dress Size," and so on. The basic message is that stress is bad—but it is not always. Some stress is actually good. Without stress, we would weaken. Difficulty that can be mastered, on the other hand, facilitates growth, self-esteem, self-efficacy and resilience. A resilient person is thus not someone who avoids stress but someone who learns how to tame and master it.

A body of data, including studies of identical twins, suggests that certain personal characteristics that foster resilience may be at least partly inherited. These traits include a temperament that leads a child to confidently take on novel tasks and interact with unfamiliar people, as well as a good-natured, sociable personality and an ability to accept yourself, including your faults. Researchers are now uncovering some of the basic biology of resilience that facilitates our adaptive responses to stress [*see box on page 11*].

Beyond biology, several environmental variables affect resilience, among them family support, the stability and quality of schools, and the services in and safety of a neighborhood. For example, a loner who is unemployed will have more trouble dealing with stress and trauma than a financially secure individual in a supportive family. Weak leadership in a community and insufficient first-responder and financial resources can also compromise responses to adversity.

Some of these situational factors, along with specific character traits, may be hard to change. Nevertheless, people can learn to think and act in ways that greatly enhance resilience. Virtually anyone can become more resilient through disciplined, consistent practice. The more we activate specific brain areas through our behavior, the more neural connections form in those areas, enabling the neurons involved to transmit their messages more efficiently.

In our book *Resilience: The Science of Mastering Life's Greatest Challenges,* we identify 10 avenues for building resilience. Some of these strategies reduce stress. Others help you grow from the experience. Strategies to increase resilience include learning how to regulate your emotions, adopting a positive but realistic outlook, becoming physically fit, accepting challenges, maintaining a close and supportive social network, and observing and imitating resilient role models. We discuss each of these approaches below.

CHRIS RYAN *Getty Images*

ENGAGING in mindfulness meditation is an effective way of controlling stress.

EMOTIONAL RESCUE

THE ABILITY to regulate emotions such as sadness, anger and fear is critical for effectively coping with stress and trauma. Negative emotions are natural and often adaptive, but if left unchecked, they can seriously compromise our ability to think clearly and to make rational decisions in challenging situations.

Researchers have devised numerous strategies for regulating emotions and enhancing resilience. Two approaches that have received increasing scientific support in recent years are cognitive reappraisal and mindfulness meditation. Using reappraisal, individuals reinterpret the meaning of an adverse event so that they see it as less negative. Doing so tends to attenuate physiological and emotional reactions to the event. For example, psychologist Kevin Ochsner and his colleagues at Columbia University have shown that when people intentionally reinterpret a situation such as a rejection for a job or the loss of a friend as being less negative, they report a decrease in unpleasant emotions. Ochsner's team also found that this improvement in mood is accompanied by changes in the brain—in particular, an increase in activity in the prefrontal cortex, a center for planning, directing and inhibiting behavior, and a decrease in activity of the amygdala, a hub for feelings such as fear.

For years researchers have studied how people regulate their emotions. Individuals who frequently use cognitive reappraisal as a way to alter their emotional reactions to stress and trauma tend to report greater psychological well-being than those who do not look for neutral or positive ways to interpret their circum-

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USING A COPING STRATEGY called cognitive reappraisal, a person revises his or her interpretation of a difficult experience to make it less negative.

stances. For example, in a 2008 study we, along with psychiatrist Adriana Feder and other colleagues at the Mount Sinai School of Medicine, interviewed 30 former Vietnam prisoners of war about how they evaluated their wartime experiences. We found that most of these veterans, many of whom had been brutally tortured, had actively reappraised their imprisonment and found meaningful ways in which they had grown stronger, wiser and more resilient as a result of it. They also reported that they were now better able to see possibilities for the future, relate to others and appreciate life.

Another inspiring example of the power of meaning and purpose comes from the life of Nelson Mandela. Mandela withstood 30 years of prison with dignity and grace because his imprisonment symbolized the human struggle for equality and freedom. In the words of German philosopher Friedrich Nietzsche, "He who has a *why* to live for can bear almost any *how*."

Training in cognitive reappraisal is a component of various therapies designed to enhance well-being, strengthen resilience and reduce distress. For example, cognitive-behavioral therapies, which are effective for treating mood and anxiety disorders, teach individuals to observe their own thoughts and behaviors, to challenge their negative assessments of stressful situations and of themselves, and to replace these with more realistic and positive points of view. When faced with a highly stressful or negative episode, you may find it helpful to ask yourself, "Is there a less destructive way to look at this situation?" "Am I catastrophizing or exaggerating its potential negative impact?" and "Is there something that I can learn from this experience, or is it possible to grow stronger as a result?"

Another strategy for controlling stressful emotions is to engage in mindfulness meditation. This exercise teaches practitioners how to consciously live in the present moment rather than dwelling in the past or fretting about the future. The participant becomes an observer who learns to watch, but not judge, as the mind tends to automatically follow familiar conditioned patterns of thinking that often add to distress and maladaptive coping. Mindfulness meditation has been associated with improved ability to focus, more flexible thinking, greater psychological well-being, and better ability to cope with depression, anxiety and stress.

Brain-scanning experiments have re-

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vealed that both mindfulness meditation and training in cognitive reappraisal can increase activation of the left prefrontal cortex (a pattern that is associated with greater emotional control), a boost in positive emotions, and faster recovery from feelings such as anger, disgust and fear. Attending a workshop on mindfulness meditation is one good way to start learning how to modulate the stress response and successfully weather life's many challenges.

A GLASS HALF FULL

IN ADDITION TO ATTENUATING negative emotions, a dedicated effort to bolster positive emotions can enhance a person's ability to bounce back from difficulty. Optimism and positive emotions are strongly associated with good mental and physical health, even longevity. In a remarkable study published in 2001 developmental psychologist Deborah D. Danner of the University of Kentucky and her colleagues examined autobiographical sketches composed by 180 nuns from School Sisters of Notre Dame in Milwaukee before they took their vows of commitment to the Church and God. They found that the degree of positive emotion expressed in the sketches, which had been written decades earlier, predicted longevity. Only 34 percent of nuns whose sketches were classified in the lowest quarter of cheerfulness were still alive at age 85 compared with 90 percent who had been classified in the most upbeat quarter.

The health benefits of positive emotions probably stem from a better ability to regulate the stress response. Psychologist Barbara L. Fredrickson of the University of North Carolina at Chapel Hill and her colleagues have found that negative emotions tend to increase physiological arousal, narrow our focus of attention and restrict our behaviors to those essential for survival. Positive emotions, on the other hand, have been found to reduce arousal and broaden our focus, leading to more creative and flexible responses to stress and trauma.

Resilience is associated with realistic optimism, not the rose-colored form. Because the latter often involves ignoring negative information, people who adopt an overly buoyant outlook tend to underestimate stressful and risky situations. On the other hand, realistic optimists filter out unnecessary negative information but pay close attention to bad news that is relevant to dealing with adversity. Using a technique called cognitive-bias modification, you can, with repetitive training, learn to tune out negative words and occurrences and develop a habit of interpreting ambiguous situations in a more positive manner.

EXERCISE can strengthen attention, decision making and memory, empowering people to better shoulder stress.

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WORKING OUT YOUR TROUBLES

PHYSICAL ACTIVITY can enhance resilience, too, by protecting people (and animals) against the negative effects of stress. During the past decade neuroscientist Benjamin N. Greenwood and his colleagues at the University of Colorado Boulder have published a series of studies in rats showing that six weeks of voluntary wheel-running exercise can ward off anxiety and depressionlike behaviors, such as exaggerated fear, reduced social exploration and increased intake of morphine, that typically result from exposure to a variety of intense stressors.

In humans, aerobic exercise also has been shown to reduce symptoms of depression and anxiety. It improves attention, planning, decision making and mem-

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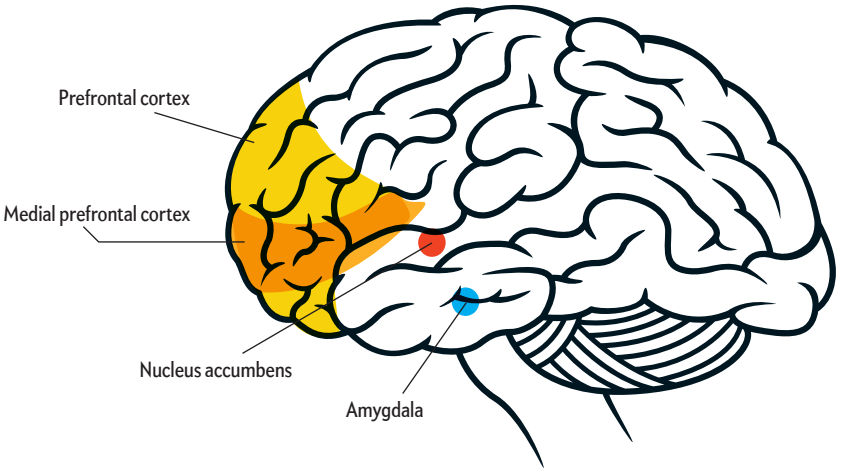
The Biology of Bouncing Back



Researchers have traced resilience, the capacity to recover from adversity, to a network of brain regions and chemicals. Beginning early in one's life, an individual's genes and the interaction of those genes with the environment shape brain circuits that underlie the psychological strengths and behaviors of resilient people.

Critical to building resilience is the capacity to face fears, experience positive emotions, search for adaptive ways to reframe stressful events and benefit from relationships. Thus, resilience relies on neural circuits governing fear, reward, and social and emotional regulation. These circuits overlap at certain brain structures. For example, the amygdala not only regulates fear but also plays a major part in reward, through the processing of positive emotions. The nucleus accumbens, the hub of reward, also influences social behaviors such as sociability and pair bonding. The medial prefrontal cortex has a role in all three circuits, helping to regulate social interactions and emotions and relaying that information to other regions to inform higher-level decisions. As a result of the overlap and connections among these circuits, how a person faces fear is correlated with his or her ability to remain upbeat under stress and generate rewarding social experiences in tough times.

The neural circuits of fear, reward and social behaviors are powered by a variety of neurochemicals and hormones. One of these, neuropeptide Y, is a short protein found in the amygdala and other regions that mediate anxiety and fear. Among people under severe stress, such as someone undergoing challenging military training, higher neuropeptide Y levels are connected to better performance. High levels of the stress hormone cortisol, however, are associated with depression. Norepinephrine, another stress hormone, helps us react appropriately to danger by readying us to fight or flee the scene. Unrestrained repeated increases in norepinephrine may create chronic anxiety, however. Dopamine and serotonin, meanwhile, help us stay positive under difficult conditions.

Resilience may also be related to activation of the left prefrontal cortex. When active, this region at the surface of the brain just behind the forehead sends inhibitory signals to the amygdala, quieting anxiety and fear-based emotions and leaving the frontal brain region free to plan and set goals. In this way, a person is better able to persevere, maintain a positive self-image, remain hopeful in stressful times, and plan and act without being overwhelmed by fear or other emotions. Understanding the biological underpinnings of resilience could help researchers and clinicians design psychological and pharmacological interventions that make people better able to overcome adversity. —*S.M.S. and D.S.C.*

ory, all of which are important for effectively managing stress. Exercise appears to promote resilience through a number of neurobiological mechanisms. For example, it boosts levels of endorphins as well as neurotransmitters such as dopamine and serotonin that may reduce symptoms of depression and elevate mood. It also suppresses the release of the stress hormone cortisol.

In addition, workouts seem to activate genes for proteins, such as brain-derived neurotrophic factor (BDNF), that promote the growth and repair of neurons, which prolonged stress can damage. In a study published in 2011 psychologist Arthur F. Kramer and his colleagues at the University of Illinois at Urbana-Champaign found that moderate-intensity aerobic exercise (three days a week for one year) increased the size of the hippocampus, a brain region involved in both memory and stress regulation, by 2 percent. This growth was associated with increases in BDNF and improved memory, suggesting that exercise can protect neurons in this area and may thus help people recover from difficult circumstances.

For general health, the Department of Health and Human Services has recommended at least one hour and 15 minutes a week of intense aerobic workouts such as swimming or running or twice as much moderately intense exercise—mowing the lawn, say, or walking fast—along with two days of muscle strengthening. (Those who work out more tend to reap greater health benefits, although very intense or prolonged athletic endeavors can actually be detrimental to physical and mental health.)

To enhance resilience, however, we recommend that you consult with your physician and then develop a schedule in which you gradually increase the intensity of your cardiovascular and strength training. Every workout should be challenging but manageable. In this way, in addition to getting the biological benefits of exercise itself, you are also carefully calibrating your exposure to stress in a way that is known to increase resilience.

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FRIENDSHIPS can lift you up, provide security and prevent a precipitous fall.

This general strategy is called stress inoculation. It is based on the notion that if a person deliberately takes on increasingly difficult challenges he or she will gradually learn to handle higher levels of stress. The inoculation principle of graded exposure can apply to a broad range of activities designed to increase physical, emotional and cognitive resilience. For example, practitioners of mindfulness can increase their ability to concentrate by gradually lengthening their periods of meditation. A person who is afraid to give speeches might sign up for a public speaking workshop and afterward accept speaking engagements in front of small, nonthreatening audiences, then gradually agree to stand up in front of larger and more challenging crowds.

Such experiences should be outside your comfort zone but not so intense as to be unmanageable or potentially harmful. You should also plan to progressively increase the intensity or difficulty of these endeavors. As noted in the *U.S. Army Combat Stress Control Handbook,* "to achieve greater tolerance or acclimatization to a physical stressor, a progressively greater exposure is required. The exposure should be sufficient to produce more than the routine stress reflexes.... In other words you must stress the system." Moreover, make training as realistic as possible. Pilots, firefighters, police and soldiers all enhance their physical, cognitive and emotional skills in realistic settings where they can obtain constructive feedback from instructors and colleagues.

As you gradually acclimate to greater levels of stress, you will need to recover and relax more. Psychologist James Loehr, who has written several books on resilience training, points out that insufficient recovery relative to the high volume of stress can be quite damaging and that one of the most important life skills may be knowing when high recovery needs to balance high stress.

FRIENDS IN NEED

A PARTICULARLY EFFECTIVE way to enhance resilience is to strengthen one's relationships because doing so can dampen your biological response to stress and bolster your courage in tense situations. High levels of social support have been associated with better psychological outcomes after many types of trauma, including childhood sexual abuse and combat. For example, in a 1998 study psychologist Lynda A. King, then at Boston University, and her colleagues found that high levels of social support after returning from war were associated with significantly lower levels of post-traumatic stress disorder among a sample of 1,632 male and female Vietnam veterans. High social support has also been linked with better overall physical and psychological health in college students, new mothers, parents of children with serious medical illnesses, widows and unemployed workers.

Backing from others is powerful because it increases an individual's self-confidence, provides a safety net if we should fall and bolsters our belief that we can overcome obstacles. As a result, we tend to more actively solve problems rather than passively avoiding challenges. After all, bonding with others does provide

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TAKING ON moderately stressful challenges, such as giving a lecture in front of a small group, can boost resilience.

greater security; a group that works closely together is stronger than an individual. On a biological level, social ties stimulate the release of the hormone oxytocin. Oxytocin is known to reduce anxiety and fear, in part by limiting the cortisol response to stress. (It also promotes affiliative behaviors and emotions, such as trust, that encourage continued socializing.)

Interestingly, social support may have an even stronger effect on coping with adversity in Latin American and other cultures that place great value on interdependence, extended kinship systems and collectivism. It plays a comparatively lesser role in more individualistic cultures such as ours, although relationships in all societies are vital.

To boost resilience through your relationships, first evaluate your social network. Make a list or map of the people you feel connected to. With whom do you interact daily? Who would help you without hesitation? To whom do you turn for advice? Who really understands you? And who can count on you for help? Resilience is strongly associated with altruism and giving support to others.

If you find you need to bolster or simply maintain a supportive network, reach out to family, friends and colleagues. Join organizations that share your interests and concerns. Find ways to help others. As an adult, it is also important to teach children the skills needed to become socially competent, such as knowing how to listen to, empathize with and give support to others.

MORE THAN FLATTERY

IN YOUR SOCIAL CIRCLES, look for people who recover quickly from hardship whom you could learn from. Members of your own family, colleagues, teachers, coaches, or even historical figures or fictional characters could also serve as resilient role models.

Psychologist Albert Bandura, the highly influential emeritus professor at Stanford University, believed that modeling was most effective when the observer analyzed what he or she wished to imitate by dissecting it into segments and creating rules that could guide future action. For example, when a friend of one of us (Southwick) lost her job, I noticed that she immediately called fellow employees, former employers and friends to solicit their help in searching for a new position. When she fell ill with pneumonia, she moved in with her sister until she recovered. And when her mother died, she called her family and closest friends and asked them to spend time with her. Rather than going it alone in times of stress, she reached out for support from those who care about her, a pattern that can guide my own behavior.

White, the land-mine survivor, is an outstanding model of resilience. Through years of soul-searching (read: cognitive reappraisal), he began to see the loss of his foot as more opportunity than horrendous misfortune. Together with a group of like-minded individuals, he embarked on a quest to rid the world of land mines. Through thoughtful reassessment, social support and a problem-solving approach, White transformed his tragedy into a mission of hope. SA

Steven M. Southwick is Glenn H. Greenberg Professor of Psychiatry, PTSD and Resilience at the Yale University School of Medicine and the Yale Child Study Center.

Dennis S. Charney is Anne and Joel Ehrenkranz Dean and Professor of Psychiatry, Neuroscience, and Pharmacology and Systems Therapeutics at the Icahn School of Medicine at Mount Sinai. They are authors of *Resilience: The Science of Mastering Life's Greatest Challenges* (Cambridge University Press, 2012; second edition is due out March 2018).

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HOW TO SUCCEED AT WORK

YOUR FERTILE BRAIN AT WORK

Scientists have mapped the innovative mind so that we can remake our own in its image

By Evangelia G. Chrysikou

BE A BETTER YOU

Illustration by MCKIBILLO

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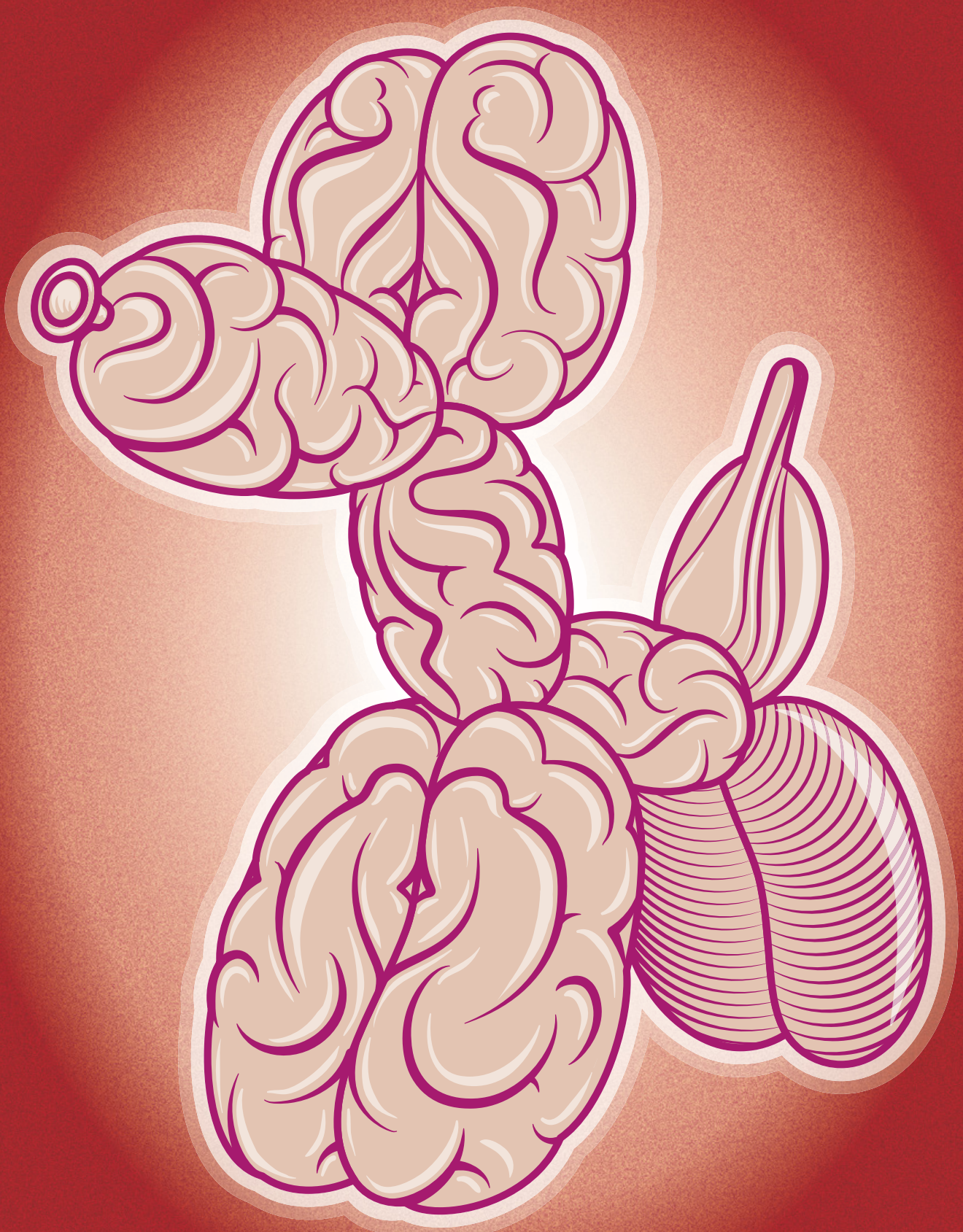

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DURING THE JULY 4TH WEEKEND OF 1994, WHILE RIDING IN A 1988 CHEVY Blazer with his wife at the wheel, a computer engineer named Jeff Bezos laid the groundwork for a retail revolution. Back then, the Internet was an insider's tool, largely limited to government and academic circles. But after months of careful observation of its usage, Bezos envisioned a dramatic expansion of this network, one that would bring it into the daily lives of ordinary people. In the car, he sketched out a business plan for a project that would realize his vision: the Internet, he understood, could boost the efficiency of mail-order businesses, starting with books.

In a risky move, Bezos and his wife, Mackenzie, left lucrative jobs in New York's financial sector to build an Internet-based bookseller headquartered in Seattle. They called it "Amazon," after the interminable South American river and its many branches. After a few months of testing and without any advertising, the company started racking up $20,000 weekly in sales. In just a few years Amazon was worth billions. Bezos forever changed how people purchase goods and made a lasting impact on the business world.

For entrepreneurs worldwide, Amazon.com is a model of innovation. Yet creativity can come in many forms. Consider Procter & Gamble's line of Swiffer products: a reconceptualization of mops, sweepers and dusters based on the simple insight that cleaning with disposable parts makes the job easier and more fun. Designer Gianfranco Zaccai of Herman Miller and his team are credited with inventing Swiffer, which reaps more than $500 million in annual sales.

Innovation matters in an enormous variety of professions. It elevates the careers of chefs, university presidents, psychotherapists, police detectives, journalists, teachers, engineers, architects, attorneys and surgeons, among other professionals. The contributions of creative thought can directly translate into career advancement as well as financial rewards. In an unfavorable economic climate, raising your creative game may even mark the difference between survival and failure.

Psychologists broadly define creativity as the purposeful generation and implementation of a novel idea. In the workplace, it may be more aptly characterized as the effortful pursuit and implementation of novelty that results in measurably useful outcomes. In numerous studies over the past few decades psychologists have tried to unravel the mysteries of exceptional creativity in the arts or sciences, considering the likes of Pablo Picasso, Mozart, Virginia Woolf, the Wright brothers and Albert Einstein. These investigations, along with others into the origins of every-

IN BRIEF

Innovation matters in an enormous variety of professions. It elevates the careers of chefs, university presidents, psychotherapists, police detectives, journalists, teachers, engineers, architects, attorneys and surgeons, among other professionals. **Although creativity** was long considered a gift of a select minority, psychologists have now revealed its seeds in mental processes—such as decision making, language and memory—that all of us possess. **Techniques** for boosting creative potential may involve breaking down established ways of viewing the world or invoking unconscious thought processes.

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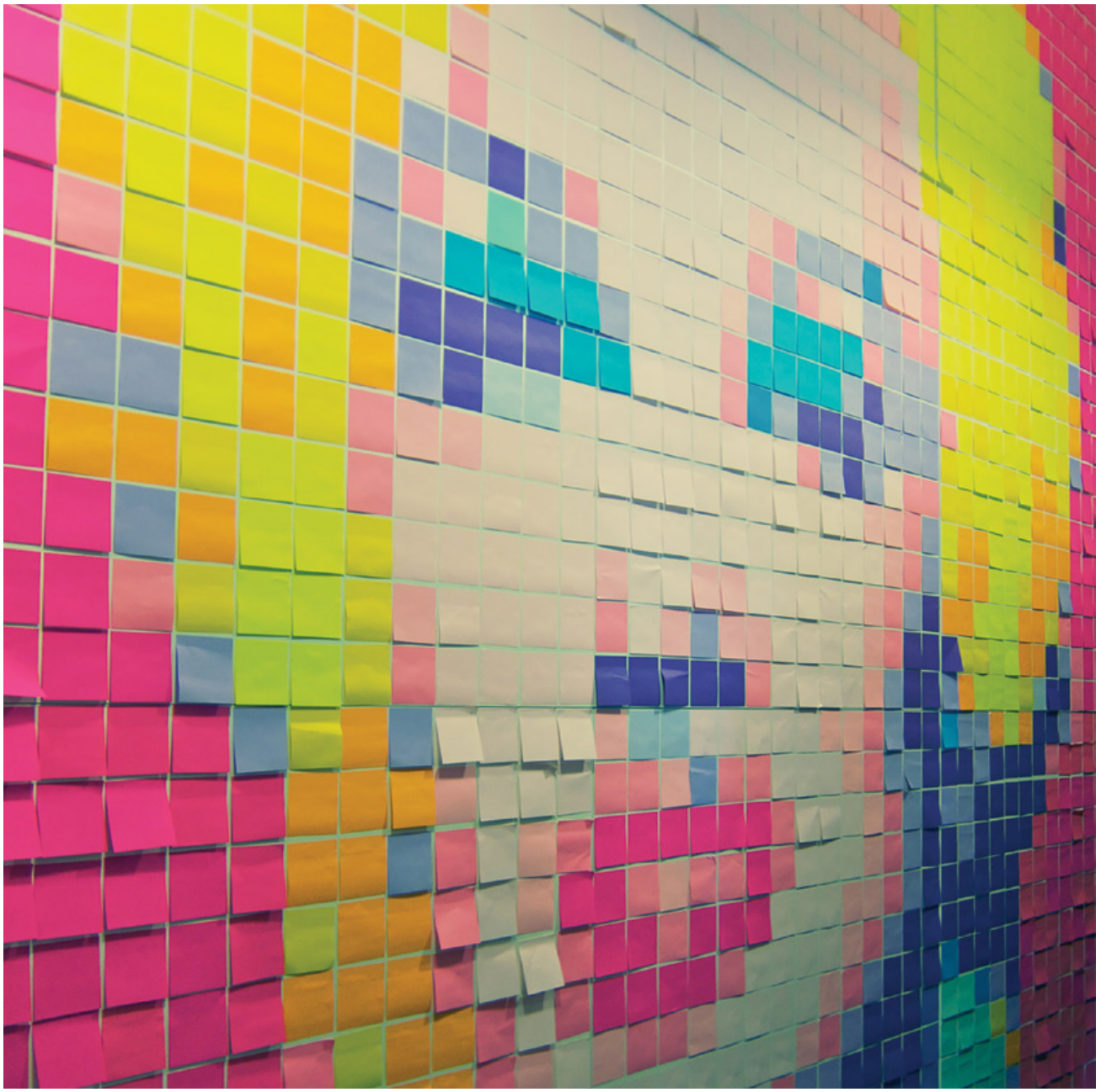

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GENERATING novel applications for objects—such as this use of sticky notes in a mural—seems to benefit from less filtering of knowledge and experiences. A more porous mental filter enables us to consider a greater variety of possible solutions.

day problem solving, have uncovered genetic, social and economic factors (as well as lucky circumstances) that contribute to creative thought.

Although creativity has long been considered a gift of a select minority, psychologists are now revealing its seeds in mental processes, such as decision making, language and memory, that all of us possess. Thus, we can all boost our creative potential. Recent studies have shown promise for techniques that break down people's established ways of viewing the world as well as strategies that encourage unconscious thought processes. Read on to try these at home—or at work.

AN OPEN MIND

ICONIC INDIVIDUALS such as Bezos, the late Steve Jobs, Martha Stewart, Steve Ells (founder of Chipotle Mexican Grill restaurants) and many others have inspired entrepreneurs and professionals to hone their creative skills. Individuals and companies have typically used creativity workshops, brainstorming sessions, self-help books, training videos and even hypnosis as vehicles for such improvement. Whether such practices influence the likelihood of creative leaps is unknown. Yet psychologists and neuroscientists have made some important discoveries that can help us understand the states of mind that benefit creative thought.

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When people consider creativity, they generally think of the birth of novel ideas. Idea generation is indeed the first important stage of the creative process. To come up with new ideas for achieving a goal, you need, roughly speaking, an open mind—that is, one guided by minimal rules and constraints. In 2009 neuroscientist Sharon Thompson-Schill of the University of Pennsylvania and her colleagues proposed that creative inspiration might benefit from a state of lower cognitive control—that is, fewer restrictions on your thoughts and behavior.

Your more prosaic, rule-guided thought is associated with a burst of activity in your prefrontal cortex, a region on the surface of the brain behind your forehead that regulates your decisions, thoughts and actions. When you abandon rules or blur your attentional focus, this region quiets down. Thompson-Schill's team called this resulting state hypofrontality and hypothesized that it holds various benefits for language learning and creative thought, among other aspects of cognition.

Researchers found early hints of hypofrontality in the mid-1990s, when they measured the electrical activity in the brains of people who were generating new ideas. By picking up electrical waves on the scalp, scientists can get a sense of a person's "brain state," say, awake or asleep, focused or relaxed. When someone is engaged in a task that requires cognitive control and focused attention—for instance, solving a math problem or deciding what to pack for a camping trip—so-called beta waves, which oscillate at a frequency of 15 to 20 hertz, usually dominate. When people came up with new ideas, however, researchers recorded alpha waves over the prefrontal cortex. These eight- to 12-hertz waves are typically a sign of relaxed wakefulness and diffuse attention. Their presence thus bolstered the notion that idea generation is associated with a state of lower cognitive control.

The behavior of patients whose frontal lobes have partially degenerated as a result of frontotemporal dementia or similar disorders is consistent with this view. These individuals show severe impairments in regulating their thoughts and actions but may experience spontaneous musical or artistic creativity they lacked before they got sick.

More recent data strengthen the case for the importance of hypofrontality in everyday creativity. In a study published in 2011 Thompson-Schill and I showed participants pictures of ordinary objects (tissues, for example) and asked them to tell us either a common use (wiping your nose) or an uncommon application (protective stuffing for a package) for each one. Participants who came up with unusual uses for the items showed minimal activity in prefrontal brain regions and heightened activity in posterior brain regions that are typically in charge of visuospatial skills. In contrast, those who thought of typical uses showed the reverse pattern. Thus, generating novel applications for objects also seems to benefit from less filtering of knowledge and experiences, which enables people to consider a greater variety of possible answers.

What is more, innovative ideas can arise from paying attention to the visual properties of things, such as their shape, size and material makeup. Instead of highlighting previous knowledge, the brain enters a state that emphasizes often overlooked perceptual elements.

Scientists have been able to mimic this brain state by applying electrical stimulation to the scalp and thereby improving problem-solving ability. These data lend considerable credence to the idea that diminished activity in the prefrontal cortex, particularly on the left side of the brain, underlies an important part of the creative process [*see box on opposite page*].

HANS NELEMAN *Getty Images*

IF YOU are struggling with a difficult project at work, take a break. The recess may shake loose some creative thoughts, especially if you choose to do something dramatically different from what your job entails.

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Tickling the Brain

Neuroscientists have been able to tweak the creative process by enhancing or suppressing activity in frontal brain regions. In a technique called transcranial direct-current stimulation, minute amounts of electric current flow through a pair of electrodes affixed to the scalp and thereby either raise or lower activity in the underlying brain regions.

In a study published in 2011 neuroscientist Allan W. Snyder of the Center for the Mind in Sydney and his colleagues used this method to affect the ability of individuals to solve arithmetic puzzles involving matchsticks. The initial problems could all be solved using a similar strategy, but the last two required abandoning what had worked before and developing a novel approach. Snyder's team hypothesized that the right hemisphere enhances creativity, whereas the left hemisphere impedes it. Indeed, when the researchers depressed activity in the left frontal cortex while exciting the right frontal cortex in some of their subjects, these individuals solved the last two problems at higher rates than those who received the opposite pattern of stimulation (left excitation, right inhibition) or sham stimulation.

Beyond fostering alternative problem-solving strategies, this neurostimulation technique can also support the generation of novel ideas, such as finding new uses for objects. In a 2013 study my colleagues and I inhibited neural activity in the left prefrontal cortex of participants while they came up with a common or an uncommon use for objects presented to them in pictures. These individuals thought of significantly *more* uncommon uses—and did so about a second faster—than did people who received inhibitory current over their right prefrontal cortex or those who were given sham stimulation. These results strongly support the hypothesis that blocking cognitive filtering by inhibiting the left prefrontal cortex during idea generation can promote creative thought. —*E.G.C.*

Type	False statement	Solution
1		
2		
3		

THOUGHT CONTROL

IN ADDITION to idea generation, true creativity involves evaluating your options, picking the best one and implementing a plan for realizing your vision. This evaluation process, the second critical stage of creative thought, involves a mental state in which the cognitive filter in the prefrontal cortex is on instead of off. In a study published in 2011 psychologist Kalina Christoff of the University of British Columbia and her colleagues asked college students from the Emily Carr University of Art + Design in Vancouver to generate illustrations for book covers on a special drawing tablet while inside a brain scanner. The students were asked to come up with ideas for their sketches for 30 seconds and then spend 20 seconds evaluating what they had sketched. The researchers found that the prefrontal cortex, among other regions, was more active during the evaluation stage, suggesting that the executive-control network that filters data and exerts brakes on behavior is *more* engaged during the evaluative phase of the creative process.

Creative individuals may thus be those who are better able to upregulate or downregulate their cognitive-control system depending on the demands of the situation—a skill known as cognitive flexibility. In a 2010 study Darya Zabelina and Michael Robinson, both then at North Dakota State University, first assessed the creativity of 50 undergraduate students using standard paper-and-pencil tests and then measured their capacity for cognitive control with the Stroop task. In this task, people are given a list of color words ("yellow," "blue," "red," and so on) that are typed in a color that often does not match the word. The goal is to state the color of the word regardless of what the word says. The task measures how well a person can filter out irrelevant information to focus on what is important, a major feature of cognitive control.

Although creative and noncreative subjects performed equally well on this task overall, creative subjects did better every time they had to switch from a matching combination (for instance, the word "red" appearing in red type) to a clashing one ("red" shown in blue letters). These results indicate that creative people show greater cognitive flexibility, which can support the ability to both generate novel ideas and put these ideas into action.

Psychologists have been exploring ways to expand our creativity, enhancing the arsenal of techniques that promote idea generation and implementation. Some of these methods appear in the sections that follow.

MENTAL PUSH-UPS

EXERCISES that shake up people's typical ways of thinking can help put them in a creative mindset. A version of the alternative-uses task described earlier, for example, can get people to rethink the way they categorize objects. In a study published in 2006 my colleagues and I asked college students to devise up to six alternative uses for 12 common objects in 15 minutes. Then we asked them to solve practical problems, such as affixing a candle upright on a wall using a book of matches and a box of tacks. (Hint: think of the box as a platform.)

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WORKING ALONE is usually the best way to come up with creative solutions. Once you have some ideas, casual interactions with others can help you develop them.

MATT HENRY GUNTHER *Getty Images*

For some of the students, the objects in the first task were related to the practical problems; for others, they were not. These two groups did equally well on the practical problems, however, and both solved significantly more of them than did students who had not completed the alternative-uses task. Thus, the training task seemed to benefit our subjects more generally, putting them in the right state of mind for creative problem solving.

Another method for boosting creativity might be to describe objects in unusual ways—for example, in terms of their features rather than their function. In a 2012 study psychologist Tony McCaffrey of the University of Massachusetts Amherst trained students to define objects generically by their shape, size and materials. A candle might be described as wax and wick or, even more obscurely, as string and cylindrically shaped lipids. McCaffrey encouraged the students to ask themselves, "Can I break the description down any further?" and "Does my description imply a particular use?" Participants who received this training showed a 67 percent boost in problem-solving performance relative to those who did not. One reason for their advantage: they were more likely to notice obscure features of the problems that were necessary for their solution.

Performing common tasks in an unconventional order can also upset your ordinary thought processes and thereby raise your creative prospects. In a 2012 study psychologist Simone Ritter of Radboud University Nijmegen and her colleagues asked a group of students to prepare a breakfast sandwich with butter and chocolate (a popular combination in the Netherlands). Half of them made the sandwich the regular way, and the rest were prompted to do so following an unusual sequence of steps. All the students were then given two minutes to generate uses for a brick and another two minutes to come up with as many answers as they could to the question "What makes sound?" Those who made the sandwich in an unconventional way—an activity that violated their expectations, the researchers theorized—came up with more different types of answers and thus scored higher on cognitive flexibility.

If mental exercises are not giving you enough good ideas, try enlisting your unconscious. One trick for achieving this mental power shift is to sleep on the problem. In particular, the stage of sleep known as rapid eye movement or dream sleep can help establish associations between remote ideas. These links may bring out solutions to conundrums that stumped you just before dozing off.

Similar benefits can come from letting your mind wander or deliberately distracting yourself. In a 2006 study psychologist Ap Dijksterhuis, also at Radboud University, and his colleagues asked people to generate novel names for products. Those who were sidetracked by a different task thought of more original names than those who worked on the problem continuously. In later studies, Dijksterhuis's team demonstrated that unconscious processing could yield answers to very difficult problems that require an extensive search of stored knowledge. These results suggest that if you are stuck on a hard problem, it pays to take a break and do something else.

What you do during your break turns out to be important, too. In a 2009 study psychologist Sophie Ellwood, then at the Center for the Mind in Sydney, and her colleagues asked partic-

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Aim to Innovate

Try these tips to maximize your creativity at work

Become an expert. A solid knowledge base will allow you to connect remote ideas and see their relevance to a problem.

Observe. When trying to come up with a new product or service, carefully study how people use what is currently available and what problems they face.

Know your audience. Walk in the shoes of the intended consumer. How would a child use a remote control? How would an elderly person access a voting booth? How can I make this dessert for a vegan?

Step out of your comfort zone. Seek activities outside your field of expertise. Take a class; read a book; travel to a foreign country. New experiences often bring forth novel thoughts.

Be willing to work alone. Group brainstorming can help you synthesize your ideas, but it is far more effective if you have started the creative process on your own.

Talk to outsiders about your work. A novel perspective can help you see alternative solutions or possible faults with your original idea.

Have fun. A good mood can forge remote associations. Upbeat music may help but also makes tasks that demand focus more difficult. If you need to concentrate, dampen your demeanor with sad songs.

Take a nap or let your mind wander. Sleep and daydreaming can enlist your unconscious mind to work on a problem that is stumping you.

Take a break. Occupying your mind with a different task can unleash novel solutions.

Challenge yourself. Disrupt your daily routine. Abandon your initial idea (even if it works) and look for a new one. Borrow from other people's answers and try to improve on them.

ipants to think of as many uses as they could for a piece of paper. Some performed the task continuously for four minutes; others paused after two minutes and did a similar exercise (thinking of synonyms for words) for five minutes before getting back to the paper task. A third group used the break to complete a personality questionnaire. The people who took a break generated more uses for the paper than those who were not interrupted, but those who did the unrelated activity performed the best on this creative task.

KEEPING YOUR DISTANCE

MANY OTHER social and emotional factors can spur creative thought. One of them is thinking of a problem as physically far away. Psychologist Lile Jia, then at Indiana University Bloomington, and his colleagues gave students practical problems similar to the one involving a candle discussed earlier. They told some participants that their responses would be collected for scientists at a university a few thousand miles away and others that a research team at their own university would get the results. A third group of students received no information about the study's whereabouts. Remarkably, the students who thought they were solving the problems for the faraway investigation solved twice as many problems as the other students. The researchers hypothesized that the psychological distance caused the students to approach the problems in more abstract terms, thereby facilitating their solution.

Distancing yourself in time can also promote innovation. Psychologist Nira Liberman of Tel Aviv University and her colleagues asked participants to imagine themselves either one day or one year in the future. Then the researchers gave their subjects a series of problems to solve and asked them to imagine themselves working on them on that future day. Those who pictured themselves in the distant future solved significantly more problems than those who simply imagined the following day.

Beyond psychological distance, physical distance from others can also increase creative output. Despite its presumed benefits, group brainstorming is beneficial only after you have come up with a few solutions for a complex problem on your own, recent research has shown. In addition, brainstorming works better in the context of casual, brief semistructured social interactions such as a lunch or social gathering than in long, organized meetings. Interactions among people with varied backgrounds—say, those who have different but related fields or those who work at other places—are especially good at promoting the synthesis and development of new ideas.

But no matter how imaginative our thoughts, we still must cross one major hurdle: our fear of risk. People tend toward safe routes, yet safety is not conducive to radical new solutions. Bezos and his wife not only had to come up with the notion of Amazon. They also had to be willing to cast off their current careers to pursue an uncertain future. Amid the financial and other practical and professional constraints of most workplaces, not to speak of other life concerns, abandoning a satisfactory but safe solution to pursue a new concept may be the biggest challenge to capitalizing on creative potential. As Bezos once said, "Innovation is disruption." SA

Evangelia G. Chrysikou is an associate professor of psychology at Drexel University, where she teaches cognitive neuroscience and creative cognition. She studies how people use ordinary objects in creative ways to achieve goals and solve problems.

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HOW TO SUCCEED AT WORK

Give me a Break

A wealth of psychological research shows that mental downtime is vital for productivity and health. Some progressive companies are finally starting to listen

By Ferris Jabr

Illustrations by RADIO

THE MOMENT THAT INCITED MARK Bertolini's workplace revolution did not happen in the office, at a conference or even when he was thinking about his job—it occurred during a family vacation. But it was not a happy moment; in fact, it nearly killed him.

In February 2004 Bertolini, then 47 years old, was on a skiing trip with his family in Killington, Vt. While speeding downhill, he collided with a tree and fell 30 feet down a ravine. The plummet fractured bones in his neck and back and severely damaged nerves in his arm. Yet he lived, gradually regaining mobility despite chronic pain. Not wanting to remain on pain medications for the rest of his life, he turned to yoga and mindfulness meditation, which teaches people to observe their thoughts, feelings and perceptions as they arise without judgment or resistance.

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He was so impressed by these pain- and stress-reducing therapies that he started to wonder whether his 50,000 employees might benefit from them, too. Bertolini is chief executive officer of the health insurance giant Aetna.

By 2010 Bertolini had enlisted the help of the American Viniyoga Institute and the meditation instruction company eMindful to customize free yoga and meditation classes for Aetna employees, even providing spaces at the office to practice. And he did not stop there. He also teamed up with health psychologist Ruth Wolever, then at Duke University and now at Vanderbilt University, to formally investigate the outcomes of these innovations.

In a three-month study of more than 200 Aetna employees, individuals who engaged in meditation and yoga slept better, felt less stressed overall and had more efficient heartbeat recovery rates after stress than those who abstained. In a follow-up study involving more than 1,000 employees, presented in May 2016 at the International Congress of Integrative Medicine and Health, meditation and yoga were correlated not only with less stress but also with 47 to 62 minutes of increased productivity per week. The practices even seemed to reduce employees' spending on health care. (The studies were funded in part by Aetna and eMindful, but all were reviewed by independent committees at Duke.) "The first year after we did the program, our health care costs actually dropped as a company," wrote Bertolini in an e-mail. He attributes some of Aetna's recent success and growth to the new practices.

MANY WORKERS FEEL "TELEPRESSURE" TO STAY CONNECTED EVEN ON DAYS OFF, BUT THE BENEFITS OF BREAKS COME FROM DETACHING.

The programs have been so successful and popular that in 2016 Aetna brought on mindfulness instructor and consultant Andy Lee as its full-time chief mindfulness officer—presumably the first position of its kind in the country. "In today's workplace, we all have more information than we know what to do with, and people are always asked to do more with less," Lee says. "That taxes our minds and our bodies. Dedicated time for rest and relaxation is an ideal countermeasure."

Around the world, especially in industrial nations, overworked employees and the scientists who study them are reaching similar conclusions. A preponderance of evidence now confirms that downtime of all kinds—whether it be a meditation session, lunchtime stroll through the park or weeklong vacation—is crucial for productivity and overall health. When we are relaxing or daydreaming, the brain does not slow or stop. Rather—much as an array of crucial molecular, genetic and physiological processes transpire during sleep—many mental processes require periods of waking rest during the day. Downtime restores attention and motivation, fosters creativity, improves work efficiency, and is essential to both achieve our highest levels of performance and simply make it through the day.

UNDER PRESSURE

PSYCHOLOGISTS began formally studying the health and habits of workers during the first decades of the 20th century. Pioneering workplace psychologist Walter Dill Scott, elected president of the American Psychological Association in 1919, focused on how best to choose employees with the most appropriate skills. In the early 1900s Hugo Münsterberg published the first textbooks explicitly focused on human behavior in the workplace, a field that is now variously known as industrial/organizational, occupational or, simply, work psychology.

Although the field has long been interested in the relations among stress, rest and productivity, it was not until the 1980s and 1990s that topics such as work-related fatigue, mental breaks and work-life balance received widespread attention. In the past decade the number of studies on such issues has increased dramatically.

Researchers identify several reasons for this new emphasis, such as the growing number of couples and families in which both partners are managing full-time careers, as well as the rising prevalence of white-collar desk jobs in which the psychological toil of work takes precedence over the kind of physical repercussions associated with hard labor. But the biggest impetus is probably the advent of technology that makes it possible to keep working 24/7 and remain in touch with colleagues even when far away from the office. "We've created a culture of immediate responsiveness," says Leslie A. Perlow, a professor at Harvard Business School. "It's getting to the point where thanks to mobile devices we can work from anywhere, and we can interrupt one another anytime."

Studies confirm that many modern employees, especially in the U.S., are perpetually preoccupied with work: even when they get a break, they feel obligated to keep working. The European Union mandates 20 days of paid vacation, but the U.S. has no federal laws guaranteeing paid time off, sick leave or breaks for national holidays. Canada, Japan and Hong Kong mandate just 10 or fewer days of annual vacation; in the U.S., workers receive an average of just eight days after one year on the job. But a 2014 survey by Harris Interactive found that we use only half of our eligible vacation days and paid time off. A 2015 report by Expedia showed that Americans collectively neglect 1.3 million years of vacation annually. And in several surveys, U.S. workers

IN BRIEF

Technology and globalization have increased pressure to stay connected to work 24/7, which may explain why American workers, on average, take only half their available vacation days and work throughout sick leave and holidays.

Time off boosts productivity and job satisfaction—but the effects can be short-lived. An optimal strategy involves taking frequent, short breaks throughout the year.

Simple daily practices such as naps, meditation or a walk outside can help people refresh their attention before returning to desk work.

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have confessed that they do not fully unplug from phone or e-mail even when they are on vacation or sick leave.

Larissa Barber, a workplace psychologist at Northern Illinois University, and her colleagues recently coined a new term for such feelings: workplace telepressure, a nagging preoccupation with work-related e-mails and related communications, combined with a compulsion to respond immediately. "All of this is tied to the American culture of busyness," Barber says. "Being busy means status and prestige, and if you are not busy and overwhelmed, it means you're not important or not working hard enough."

In a survey of more than 300 part- or full-time workers published in 2015 in the *Journal of Occupational Health Psychology,* Barber and her colleagues found that employees who reported greater workplace telepressure missed more days of work, experienced more physical and mental burnout, and did not sleep as well as their less e-mail-obsessed peers. Barber also suspects that telepressure can lower the quality of an employee's work. "Responsivity doesn't always mean productivity," she says. "All it shows is that someone is responding and available, but that is different from doing good work."

The increasingly intrusive nature of work-related communication is especially troubling in light of one of the strongest conclusions from the past decade of occupational psychology research: to maximize the benefits of breaks, we need to fully disengage from our jobs—physically and mentally. "No matter how we look at it, detachment is good for well-being," says Charlotte Fritz, an organizational psychologist at Portland State University, who published a review paper on the topic in 2015. "The benefits include lower exhaustion, higher positive mood, better sleep and better quality of life."

THE (QUALIFIED) CASE FOR MORE VACATION

PERLOW AND HER COLLEAGUES have conducted some of the most rigorous research on how uninterrupted downtime improves health and productivity. In one four-year study, she and her team monitored the work habits of employees at the Boston Consulting Group, who were used to working nearly nonstop. Every year the researchers insisted that employees take regular time off, even when they felt they should be in the office. In one experiment, published in 2009 in the *Harvard Business Review,* each of four consultants on a team took a break from work one day a week. In a second experiment, every member of a team scheduled one weekly night of inviolable personal time.

Everyone resisted at first, fearing that work would pile up. But the consultants gradually came to love their mandated time off because it restored their willingness and ability to work, making them more productive overall. After five months the study subjects were more satisfied with their jobs, more likely to see a long-term future at the company, more satisfied with their work-life balance and prouder of their accomplishments. These initial experiments were so successful that within four years, the Boston Consulting Group had implemented the same practices in more than 2,000 teams in 66 offices in 35 countries.

Collectively, studies by Perlow and other researchers suggest that the current model of consecutive 40-hour workweeks, punctuated by two-day weekends and one or two vacations a year, is not ideal for mental health or productivity. Psychologists have established that, like weekends and evenings, vacations have genuine physical and psychological benefits: they reduce stress, promote creativity and revitalize attention.

Yet a comprehensive meta-analysis, published in 2011 by Jessica de Bloom, a psychologist now at the University of Tampere in Finland, demonstrates that these benefits generally fade within two to four weeks. In one of her own studies, for example, 96 Dutch workers reported that compared with their typical daily experience they felt greater energy and happiness, less tension and more satisfaction with life during a winter sports vacation between seven and nine days long. Within just one week of returning to work, however, all sense of renewal had vanished. A second experiment on four and five days of respite came to essentially the same conclusion.

A vacation is like applying a single ice cube to a burn: it will help for a little while, but soon enough the ache returns. The

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U.S. standard of two weeks' annual vacation time is nowhere near enough to sustain such ephemeral benefits throughout a given year because it allows for too few discrete breaks. And many people save up their scant vacation time to use all at once. "It's not necessarily true that longer breaks or holidays have better results," de Bloom says. "It seems that regularity is much more important."

Given the current work climate, the prospect of frequent breaks during which employees disconnect *completely* from their jobs may seem unlikely, but it is a much more pragmatic and affordable strategy than lengthy vacations. Baby steps involve curtailing job-related communications in the evenings and on weekends.

Some companies do set boundaries on work e-mail: in 2011, for example, Volkswagen prevented employees from accessing work-related e-mails on company-issued phones during nonwork hours. France and Germany have restricted after-hours work communication in certain sectors or situations. But such practices are the exception. In one 2012 survey, only 21 percent of organizations had a formal policy limiting use of work-issued mobile devices during off-hours.

On an individual level, Barber recommends strictly managing expectations. Replying too quickly often sets up unrealistic standards. On her class syllabus, she explicitly states when she is available to reply by e-mail and when she is not. Meanwhile de Bloom spreads her vacations as much as possible throughout the year. And her polite but firm out-of-office e-mail response cites studies on the benefits of mentally detaching from work during vacation.

HITTING REFRESH

WEEKENDS AND HOLIDAYS ASIDE, simple daily practices can allow employees to mentally detach from their desk work. Tony Schwartz, a journalist and CEO of the Energy Project, has made it his mission to advise people on implementing these practices. Building on the available science, his company provides coaching and consultations for organizations that want to help individuals avoid burnout and dissatisfaction.

The Energy Project instructs workers to get seven to eight hours of sleep each night, use every vacation day, take naps and other small breaks throughout the day, learn to meditate and take on the most challenging projects first to give them maximum attention. Although their approach counters the reigning cultural conviction that busier is better, the organization has partnered with Google, Apple, Facebook, Coca-Cola and a wide range of Fortune 500 companies. According to Schwartz, their strategies have pushed workers' overall engagement well above average levels (as measured by self-reports of how much people enjoy their job and are willing to take on extra duties). Google maintained the partnership for more than five years.

More than a decade of research has uncovered the fact that although our mental resources gradually ebb from dawn to dusk, breaks can restore at least some of these cognitive faculties. Naps, for instance, can sharpen concentration and improve the performance of both the sleep-deprived and fully rested on all kinds of tasks. In a 2002 study, 26 physicians and nurses working three consecutive 12-hour night shifts dozed for 40 minutes at 3 A.M. while 23 of their colleagues worked continuously without sleeping. Although doctors and nurses who had taken a siesta scored lower than their peers on a memory test at 4 A.M., at 7:30 A.M. they actually outperformed their counterparts on a test of attention, more efficiently inserted a catheter in a virtual simulation and appeared more alert during an interactive simulation of driving a car home.

Some start-ups and progressive companies provide employees with spaces to nap at the office, but most workers in the U.S. do not have that option. Another restorative solution is spending more time outdoors, away from man-made spaces. Marc Berman, a psychologist at the University of South Carolina, studies

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the hypothesis that natural environments restore our attention. Built-up environments, such as crowded city streets, he argues, may overwhelm the brain with noisy, glaring stimuli, whereas the calm and quiet of green spaces, such as parks and forests, allow the mind to relax and recuperate.

In one of the few controlled experiments in this area, published in 2008, Berman asked 38 University of Michigan students to complete two attention-draining tasks: first studying lists of numbers and reciting them from memory in reverse order, then memorizing the locations of words in a grid. Half the students subsequently ambled along an arboretum path for about an hour, and the other half walked the same distance through busy downtown Ann Arbor. Back at the laboratory the students once again memorized and recited strings of numerals. On average, the volunteers who had spent their time amid trees rather than city traffic recalled 1.5 more digits than the first time they took the test; those who had walked through the city improved by only 0.5 digit—a small but statistically significant difference between the two groups.

IN ONE STUDY, MEDITATION AND YOGA WERE CORRELATED NOT ONLY WITH LESS STRESS BUT ALSO WITH 47 TO 62 MINUTES OF INCREASED PRODUCTIVITY PER WEEK.

CLEARING THE MIND

IN ADDITION TO ENHANCING one's powers of concentration, downtime can strengthen attention—something that scientists have gleaned through studies of meditation. In the past decade mindfulness training has become incredibly popular as a strategy to relieve stress, exhaustion and anxiety—especially for overworked nine-to-fivers (or nine-to-niners, as is often the case).

Critics of mindfulness research observe, correctly, that studies on the benefits of this practice are typically small and that they lean on subjective reports; the science of mindfulness is still not a rigorous one. Nevertheless, at this point researchers examining the benefits of mindfulness have gathered enough evidence to conclude that meditation can improve mental health, hone concentration and strengthen memory. Experiments that contrast longtime expert meditators with novices or people who do not meditate often find that the former outperform the latter on tests of mental acuity.

In a 2009 study, for instance, neuroscientist Sara van Leeuwen, then at Goethe University Frankfurt in Germany, and her colleagues tested the visual attention of three groups of volunteers: 17 adults around 50 years old with up to 29 years of meditation practice; 17 people of the same age and gender who were not longtime meditators; and another 17 young adults who had never meditated before. These participants viewed a series of letters flashed on a computer screen, concealing two digits in their midst. Volunteers had to identify or guess both numerals; recognizing the second number was often difficult because earlier images masked it. Performance on such tests usually declines with age, but the expert meditators outscored both their peers and the younger participants.

Changes to the brain's structure and to behavior most likely explain these improvements. Over time expert meditators may develop a more intricately wrinkled cortex—the brain's outer layer, which is critical for many sophisticated mental abilities, such as abstract thought. These practitioners may also have increased volume and density in the hippocampus, an area that is absolutely crucial for memory. Finally, meditation appears to thicken regions of the frontal cortex that we rely on to regulate our emotions and prevent the typical wilting of brain areas responsible for sustaining attention as we age.

At this point, scientists are still unsure of how quickly these changes occur, although some studies suggest that a few weeks of meditation or a mere 10 to 20 minutes daily can sharpen the mind. But there is likely a catch: as with vacations, a few studies indicate that regularity is ultimately more important than the length of any one session. Just 12 minutes of daily mindfulness meditation helped to prevent the stress of military service from corroding the working memory of 34 U.S. marines in a 2011 study conducted by Amishi Jha, now at the University of Miami, and her colleagues. Jha likens mindfulness training to push-ups: as a mental workout, she says, "it's low-tech and easy to implement." In her own life, she looks for any opportunity to practice, such as her 15-minute daily commute.

Since Bertolini introduced mindfulness and yoga courses to Aetna, more than 13,000 employees have participated. Now the company is deciding how best to extend these benefits beyond their offices to their 23 million health insurance members. "There's been this incredible trajectory in peer-reviewed work on mindfulness and related relaxation techniques in the workplace," says Wolever, the former Duke researcher who studied Aetna employees. "We need to work against that culture of always being busy and develop more realistic expectations of what our brains and bodies can handle." SA

Ferris Jabr is a contributing writer for *Scientific American*. He has also written for the *New York Times Magazine*, the *New Yorker* and *Outside*.

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HOW TO SUCCEED AT WORK

THE POWER OF REFLECTION

Insight into our own thoughts, or metacognition, is key to high achievement in all domains

By Stephen M. Fleming

Photography and Photo Illustration by Brandon Hill

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JUDITH KEPPEL WAS A SINGLE QUESTION AWAY FROM TAKING HOME £1 MILLION. She was in the final round of a British quiz show, and she had to face one last challenge to become the show's first victor: "Which king was married to Eleanor of Aquitaine?"After a brief discussion with the show's host, Chris Tarrant, she settled on Henry II. Then Tarrant asked her the killer question, the moment when contestants often agonize the most: "Final answer?" Without missing a beat, Keppel confirmed. The audience broke into cheers as it was revealed she had won. Keppel did not waver on that November day in 2000 because of her metacognition. The term, coined by psychologist John Flavell in the 1970s, refers to our ability to evaluate our own thinking. Is the answer to a password prompt correct? Is a particular memory from childhood accurate? Will we find it easy or difficult to learn a new language? Metacognition is an internal tribunal that rules on the soundness of our mental representations, such as a memory or judgment. Keppel's metacognition gave her answer a resounding endorsement.

This knack for reflecting on our thoughts is often viewed as a hallmark of the human mind. It is also a vital survival skill. Metacognition is how we identify our limitations and compensate for them. A student who thinks she is unprepared for a chemistry exam, for example, can devote an extra evening to brushing up on atomic orbitals. When you set an alarm to remind yourself of something you suspect you will forget or make a to-do list to keep track of the day's activities, metacognition has stepped in to save you from your own deficiencies.

Metacognition is not only for spotting weakness. It also kicks in when you assess your strengths, such as when a new swimmer kicks off his floaties or a budding cyclist removes the training wheels. A person with accurate metacognition can move on to the next challenge as soon as she is ready, wasting no time in her journey to mastery.

Ultimately metacognition serves as a foundation for learning and success. When it is impaired, however, performance in school or at work may suffer.

IN BRIEF

Metacognition is the ability to make judgments about our own thoughts—for example, assessing whether a memory is accurate or a decision is appropriate.

People vary in the accuracy of their metacognition. Certain psychological disorders, including dementia and schizophrenia, can impair this ability.

Several strategies appear to shore up metacognition, including meditation and taking breaks while studying to reflect on one's own learning.

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You become less able to recognize a bad decision and correct course. Several psychiatric disorders include deficits in metacognition, which can prevent individuals from identifying their own problems. But with new techniques to quantify metacognition in the laboratory and relate it to brain function, researchers are beginning to understand how metacognition works and why it might go awry. Centuries after Socrates counseled the average Athenian to "know thyself," psychologists are discovering the tools to do a better job of it—to train metacognition and to improve our judgments of our own abilities.

THE METACOGNITIVE MIND

REFLECTING ON our own thoughts is as old as human civilization. The scientific study of it gained its first big boost from Sigmund Freud and his notion that a person's self-knowledge can be inaccurate, with a large portion of the human mind inaccessible to consciousness. He believed that with enough excavation, we could unearth the hidden forces guiding our actions, thereby bringing our true beliefs into the light of consciousness. Yet psychologists came to realize that such analysis was unreliable, and pure introspection as a method for gaining insight into our own minds was gradually discarded.

Flavell, a longtime observer of child development, proposed that one aspect of introspection—metacognition—was key to educational success. In a test of memory, for example, he found that "older subjects studied for a while, said they were ready, and usually were," whereas "younger children studied for a while, said they were ready, and usually were not."

His observation hinted that as the brain matures, certain areas or networks might need to firm up in young minds for children to become better judges of their own learning. To study this idea in the lab, however, researchers have had to grapple with a conundrum: how to test people's thoughts about their thoughts.

Because there are no obvious markers of metacognition, my colleagues and I use a shortcut. We measure individuals' confidence in a judgment and see whether their certitude was warranted. Examples of misplaced confidence crop up in daily life all the time. When an inexperienced cook decides it is a good idea to try out new recipes on a dozen friends but then burns the salmon, undercooks the paella and forgets to dress the salad, he or she might be demonstrating poor metacognition.

ULTIMATELY METACOGNITION SERVES AS A FOUNDATION FOR LEARNING AND SUCCESS. WHEN IT IS IMPAIRED, HOWEVER, PERFORMANCE IN SCHOOL OR AT WORK MAY SUFFER.

In my studies, the task is much simpler than pulling off a four-course meal. Participants sit in front of a computer screen and see two big circles flash briefly. The circles are filled with dots, and the goal is to decide which patch contains more dots. Most people find it pretty challenging. Getting the answer right is not what interests me here—I want to know how sure people are of their selections. Trial after trial, subjects pick circles and rate their faith in their answers, and eventually a pattern emerges. If your confidence is high only when you do well, and vice versa, your metacognition is in fine form. Similar test set-

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ups can quantify metacognition related to other aspects of behavior, such as learning and memory.

Using such experiments, my colleagues and I have found that metacognitive accuracy varies widely across the population. Some people have very poor insight into their own thinking, whereas others appear capable of excellent mental self-assessment. Yet it is important to note that a person's metacognitive prowess does not predict performance. You can have little concept of your own skill level but do a marvelous job of counting dots (or throwing dinner parties).

THE ANATOMY OF INSIGHT

USING THE TOOLS of contemporary neuroscience, scientists are now beginning to identify the brain mechanisms that govern metacognition. The first clues came from patients with a peculiar form of brain damage. In the mid-1980s neuroscientist Art Shimamura was a postdoctoral student working with Larry R. Squire of the University of California, San Diego. They were studying patients with amnesia, all of whom had damage to the hippocampus, a critical memory region, when they noticed an odd pattern in their data. Most of their patients had poor memory, as expected, but only some of them were aware of their problems with recall. The amnesic patients who were unaware of their deficits—they had poor metacognition—suffered from Korsakoff's syndrome, a disorder often associated with alcoholism. Patients with this condition not only become amnesic from an injured hippocampus, they also endure damage to the frontal lobe of the brain. That insight led Shimamura and Squire to suspect that metacognition is governed by the brain's frontal lobe.

To confirm their hunch, they needed to find patients with damaged frontal lobes but intact memory regions. Working with their colleague Jeri Janowsky, they found seven individuals with lesions to the frontal lobe and observed that their metacognition was indeed impaired: when the scientists showed them a list of sentences and asked them how likely they were to recognize those sentences later, the subjects made inaccurate predictions. Their memory for the sentences remained intact, however. These studies were the first to show that metacognition is an independent function of the brain and not simply part and parcel of everyday abilities.

THE KNACK FOR REFLECTING ON OUR OWN THOUGHTS IS OFTEN VIEWED AS A HALLMARK OF THE HUMAN MIND. IT IS ALSO A VITAL SURVIVAL SKILL.

The frontal lobe of the brain covers a vast swath of neural real estate, and my colleagues and I wanted to pinpoint the hubs of metacognition more precisely. Research we published in 2010 set out to do just that. In a study carried out with Rimona S. Weil, Geraint Rees and other colleagues at University College London, we briefly showed volunteers two images and asked them which one looked brighter. Then they reported how confident they were in their answer. After a series of trials, we calculated a metacognition score for every subject.

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To rule out any differences in visual perception, we made sure our subjects were equally capable of identifying the brighter patch, which they did approximately 70 percent of the time. After we scored them, we scanned their brains and found that the people with better metacognition had more gray matter in the anterior prefrontal cortex (aPFC), a brain region toward the front of the frontal lobe that is disproportionately enlarged in humans as compared with other primates. Gray matter consists mostly of neuron cell bodies, as opposed to the white matter of slender axons, which extend from the cell body and transmit electrical impulses to other neurons. More metacognitive individuals also had denser white matter tracts connecting the aPFC to the rest of the brain.

Other brain-imaging studies have suggested that neural activity in the aPFC is more tightly correlated with confidence in people who have better metacognition. In addition, zapping that general area with magnetic pulses, which temporarily interferes with the activity of neurons, has been found to impair subjects' metacognition without affecting other aspects of their perception or decision making.

Many of these studies quantify metacognition in highly artificial scenarios, and naturally my colleagues and I were curious whether the principles and brain regions we were identifying for simple judgments also play a role in more complex decisions. Together with neuroscientists Benedetto De Martino, Ray Dolan and Neil Garrett, all then at University College London, we designed a more lifelike experiment, albeit inside a brain scanner. We asked participants to decide which of two snacks they prefer, for example, Pringles versus KitKats. Then they told us how confident they felt that they had picked the superior food. After they climbed out of the scanner, they reported how much they would be willing to pay for either snack, and again they rated their confidence, this time in the dollar amounts they had named.

This elaborate procedure helped us to tease apart the brain activity supporting our decisions from the neural hubbub governing our metacognition about our actions. As it turned out, not everyone said they would pay more for the item they claimed to prefer—the seemingly

JOE RAEDLE Getty Images

Metacognition in Mammals—and Machines

Is metacognition unique to humans? We cannot ask animals for a verbal judgment about their behavior, but ingenious animal-friendly tests can nonetheless probe whether other creatures form thoughts about their own thoughts.

In a pioneering experiment, psychologist David Smith of the University at Buffalo trained a dolphin named Natua to swim toward one of two levers when he heard either a low- or high-pitched sound. When Natua answered correctly, he scored a fish. But some sounds were more difficult for him to distinguish. So Smith introduced a third lever, which triggered an easier trial and let Natua collect his fish. The dolphin learned to press this lever only on more difficult trials.

Smith reckoned that for Natua to choose the third lever, the dolphin must recognize the absence of knowledge and thus must be reflecting on how much he knows. Additional support for this conclusion came from observations that the longer the dolphin hesitated or wavered between the two response options, the more likely he was to choose the third lever. So his opt-out choices appeared to be based on bona fide feelings of uncertainty. As later experiments demonstrated, macaques also show similar metacognitive behaviors, but another species of monkey, capuchins, do not.

A different metacognition test mimics the confidence judgments we ask of humans in the laboratory. As in the dolphin experiment, an animal decides which of two answers it thinks is correct. Then it is given a chance to commit to that choice or go for a separate, safe option that always delivers a small snack. Betting on the original selection is riskier—it garners a larger treat if correct but no food otherwise. Macaques pass with flying colors: they take the riskier bet when they are more likely to be correct. The activity of neurons in the monkeys' frontal cortex also tracks their confidence, providing a window on how metacognition is implemented at the level of neural circuits. Even rats can learn to pass a version of this test.

DOLPHINS can be trained to report their confidence in their own judgments.

Yet the evidence is not enough to conclude that animals have metacognition. For one thing, the anterior prefrontal cortex, a key brain area for human metacognition, is larger in humans than in monkeys and does not exist in rats. This anatomical difference does not necessarily eliminate the possibility of introspective rodents, because metacognition might have evolved in more than one form. It might manifest both as an implicit feeling of uncertainty that animals share with us, as well as the conscious self-knowledge that might be unique to humans.

Even some computers may embody a form of metacognition. When Watson, IBM's *Jeopardy*-playing machine, beat two champion human players in 2011, it relied on a skill very similar to human self-knowledge. Watson not only came up with answers but also generated a confidence rating for them. The supercomputer then used the rating to decide whether to hit the buzzer. As it turned out, Watson knew that it knew—it calculated a rating—faster than the human *Jeopardy* champs knew that they knew, giving IBM's machine the edge it needed to win. —*S.M.F.*

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logical response. Yet some individuals were more aware than others of their inconsistent behavior. As we reported in 2013, these individuals had stronger connectivity between a region of the brain involved in value computation and the aPFC. Although they did not always make optimal choices, at least they knew they were floundering.

We still have much to learn. For example, we do not yet know how the aPFC contributes to metacognition or why greater brain volume in this region leads to changes in insight. Yet these findings are a crucial first step toward identifying ways to shore up metacognition, whose absence can produce devastating effects.

LACK OF INSIGHT

WHEN A PERSON with a disorder is unaware of his or her impairments, clinicians use the term "anosognosia," from Greek roots meaning "without knowledge of disease." Patients with dementia, for instance, may not notice that their memory is slipping away. As a result, they may not seek help, remember to take medications or recognize that they can no longer safely drive a car. Schizophrenia, addiction and stroke can also harm metacognition. A parent's or sibling's lack of insight into his or her own illness can be heartbreaking to a family, causing the shared reality on which social relationships are built to crumble.

Psychiatrists have traditionally believed that such patients were simply in denial. In this view, patients recognized their deficits but were reluctant to admit them to physicians and family members. Now, however, metacognitive failure is seen as a consequence of certain disorders. For instance, most alcoholics do not see their own drinking as problematic—even though they also believe that excessive drinking is unhealthy. As psychiatrist Rita Z. Goldstein and her colleagues wrote in 2009, "one of the greatest challenges in drug addiction treatment is that the individuals who require treatment do not even recognize the need for therapeutic help."

Whether metacognition and anosognosia are two sides of the same coin is not yet clear, although we do know they are closely related. Patients with schizophrenia who lack awareness of their illness, for example, tend to have a smaller frontal lobe than those who recognize their disorder—the same pattern seen in the healthy individuals with impaired metacognition mentioned earlier. (Because psychiatric illness has multiple effects on the brain, dysfunction in a network of brain regions most likely underpins anosognosia.)

We may learn that anosognosia is simply one kind of metacognitive failure. Recent studies hint that a person's capacity for introspection can differ across various domains; perhaps anosognosia is one such category. In support of this view, scientists have documented differences in the brain activity associated with metacognition of memory ("I doubt I'll re-

BECAUSE MEDITATION INVOLVES CONSISTENT SELF-FOCUS AND THE ABILITY TO ZERO IN ON ONE'S OWN MENTAL STATES, IT MIGHT ALSO HONE OUR SELF-APPRAISAL ABILITIES.

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member to pay the rent tomorrow, so I better make a note to myself") and metacognition of perception ("Did I really spot an endangered Henslow's sparrow—or just another humdrum song sparrow?"). My collaborators at New York University and I have similarly found that individuals with damage to the aPFC struggle with perceptual metacognition but seem to have no trouble making accurate judgments of their memories. Uncovering the neural roots of different kinds of introspective failure will help researchers home in on therapies targeting anosognosia—and potentially help patients manage their ailments or seek treatment.

A METACOGNITIVE BOOST

EFFORTS to restore metacognition first began in the late 1990s. A small-scale trial looked into the effects of clozapine, an antipsychotic drug, on people who had schizophrenia. The study found that patients' insight into clinical symptoms improved after six months of treatment. The medication also lifted their schizophrenic symptoms, so the researchers could not surmise which aspect of their recovery aided metacognition.

More recently, psychologist Robert Hester of the University of Melbourne in Australia and his colleagues found that methylphenidate (Ritalin) could enhance metacognition in healthy volunteers. In these experiments, subjects performed a difficult color-detection task under time pressure and noted whenever they thought they made an error—a metacognitive judgment. The participants given Ritalin—but not subjects given other drugs, such as citalopram, a common antidepressant—could consciously recognize more of their own errors.

Electrical brain stimulation might also serve to enhance metacognition. Using the same task, a team at Trinity College Dublin found that passing a weak electric current through the frontal cortex of elderly volunteers increased their awareness of their own errors. These weak currents temporarily excite neurons, which may place the frontal lobe in a "primed" state that improves metacognition. It may even be possible to stimulate circuits for metacognition indirectly using neurofeedback. A recent collaboration between ATR Computational Neuroscience Laboratories in Japan and the University of California, Los Angeles, used machine-learning techniques to allow participants to selectively alter neural patterns associated with confidence in their decisions.

A more readily available way to improve self-judgments is through meditation. In a 2014 study led by psychologists Benjamin Baird, now at the University of Wisconsin–Madison, and Jonathan W. Schooler of U.C. Santa Barbara, engaging in two weeks of meditation training increased metacognition during a memory test (but not during a task involving visual discrimination). Because meditation involves consistent self-focus and the ability to zero in on one's own mental states, it might also hone our self-appraisal abilities. In my lab we are developing training protocols to improve metacognition by giving people feedback, not on their performance but on the accuracy of their self-judgments. A tantalizing possibility is that such training induces plasticity in brain circuits previously identified as supporting self-reflective processes.

THROUGH THE LENS OF METACOGNITION WE EXPERIENCE OUR THOUGHTS AND FEELINGS, BUT THE FOCUS OF THIS LENS IS FINELY TUNED AND FRAGILE.

Simple psychological strategies can shore up metacognition in the classroom. In the early 1990s the late psychologist Thomas O. Nelson and his student John Dunlosky, then at the University of Washington, reported an intriguing effect. When volunteers were asked to reflect on how well they had learned a list of word pairs after a short delay, they were more self-aware than if asked immediately. Many studies have since replicated this finding. Encouraging a student to take a break before deciding how well he or she has studied for an upcoming test could aid learning in a simple but effective way.

Learners could also trigger better insight by coming up with their own subject keywords. Educational psychologist Keith Thiede of Boise State University and his colleagues found that asking students to generate a few words that summarized a particular topic led to greater metacognitive accuracy. The students then allocated their study time better by focusing on material that was less well understood.

Yet we might not always want to increase insight. In some scenarios, it might prove to be traumatic. A patient with Alzheimer's disease, for instance, may be troubled by an awareness of his or her failing memory. This and other ethical questions will need to be grappled with as the field of metacognitive neuroscience matures.

Through the lens of metacognition we experience our thoughts and feelings, but the focus of this lens is finely tuned and fragile. Overly distorted metacognition can lead to failures of self-knowledge and poor decision making. In extreme cases, such as in psychiatric disorders, a person may fail to connect with the shared social reality that others enjoy. Refocusing the lens may be the key to ameliorating some mysterious and devastating aspects of psychiatric illness. Through the marriage of cognitive neuroscience, psychology and computational models, the tools for doing so may soon be within our grasp. SA

Stephen M. Fleming is a cognitive neuroscientist who studies metacognition and consciousness. He is currently a Wellcome Trust/Royal Society Sir Henry Dale Fellow at the Wellcome Center for Human Neuroimaging, University College London, and director of the MetaLab.

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HOW TO SUCCEED AT WORK

conquer yourself, conquer the world

Self-control is not just a puritanical virtue. It is a key psychological trait that breeds success at work and play—and in overcoming life's hardships

By Roy F. Baumeister

THE ABILITY TO REGULATE OUR IMPULSES and desires is indispensable to success in living and working with others. People with good control over their thought processes, emotions and behaviors not only flourish in school and in their jobs but are also healthier, wealthier and more popular. And they have better intimate relationships (as their partners confirm) and are more trusted by others. What is more, they are less likely to go astray by getting arrested, becoming addicted to drugs or experiencing unplanned pregnancies. They even live longer. Brazilian writer Paulo Coelho summed up these benefits in one of his novels: "If you conquer yourself, then you will conquer the world."

IN BRIEF

Thirty years ago psychologists mistakenly regarded cultivation of self-esteem as a panacea for personal problems and social ills.

Self-control, not self-esteem, turned out to be the real deal. The ability to regulate impulses and desires is key to living and working with others.

The dynamics of self-control are, in fact, quite complex. Willpower can be depleted through overuse as if it were a repository of energy.

Research on self-control is now extending in new directions to provide insight into the roots of addiction and how to combat it.

Illustrations by Daniel Stolle

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Self-control is another name for changing ourselves—and it is by far the most critical way we have of adapting to our environment. Indeed, the desire to control ourselves and our environment is deeply rooted in the psyche and underlies human engagement in science, politics, business and the arts. Given that most of us lack the kingly power to command others to do our bidding and that we need to enlist the cooperation of others to survive, the ability to restrain aggression, greed and sexual impulses becomes a necessity.

Social psychologists' appreciation of the importance of self-control reflects a shift in perspective. Thirty years ago many of them mistakenly regarded cultivation of self-esteem as a panacea for personal problems and social ills—an honest mistake. High self-esteem is associated with doing well in life, so it was reasonable to assume that a boost would improve people's lives.

When analyzed more closely, the data suggested that self-esteem does not itself lead to success. It is less a cause than an effect. When researchers tracked students over long periods, they found that getting good grades results in better self-esteem later. But having higher self-esteem does not produce stellar report cards. Self-control, however, is the real deal.

Experiments on self-control began in the 1960s with pioneering studies of delaying gratification conducted by Walter Mischel, now at Columbia University. Using a procedure that came to be dubbed the "marshmallow test," he offered children a choice between immediately getting the white, cylindrical candies (or another of their favorite treats) or else receiving a couple of those same sweets if they could only wait for a while. More than a decade after these early experiments were published, Mischel and his colleagues tracked down the children, by then young adults, and did so again as they entered middle age. The ones who had the most success at resisting temptation at age four went on to be the most successful as adults.

Recognizing the requirement of self-control for well-being, I and others have set about probing the psychological and biological processes underlying it. The findings indicate that the act of opting to not express anger or of choosing to forgo a marshmallow is akin to drawing on a store of energy that gets you through mile 26 of a marathon. As with any source of energy, it becomes depleted over time and needs replenishing. What psychologists have learned about self-control in recent studies may even provide new ideas for treating the seemingly intractable challenges of drug and alcohol addictions.

MENTAL MUSCLE BUILDING

I HAVE SPENT a quarter of a century doing laboratory studies on self-control with an endlessly fascinating stream of creative colleagues. Over that time, I have come to the conclusion that self-control, which might also be referred to as self-regulation or willpower, works something like a muscle does. In particular, it seems to "tire" after a workout. Several hundred studies in many labs have now replicated the basic finding that, after exerting willpower, people have less left over to complete a second chore. In one early study, we found that people who called on their self-control to resist chocolates and cookies later showed less fortitude on a difficult problem-solving exercise. They gave up much more easily than people who had not worked their willpower "muscle." In other studies, trying to suppress a forbidden thought—such as being told not to think of a white bear—made participants less able to control subsequent emotional reactions.

We coined the term "ego depletion" to label the state of diminished willpower that follows from expending psychic energy on self-control, be it resisting temptation or forcing oneself to make tough decisions. The term was chosen as an homage to Sigmund Freud, who proposed that the self consists partly of a well of energy. His vague theories about how this energy worked are now mostly obsolete, but he did recognize that some form of psychic energy explains our behavior. Cast aside for decades, this idea reemerged when our experiments found that self-control operates as a mental muscle of sorts, a muscle in which energy stores get depleted with use.

Two other lines of research have extended the muscle analogy. Experiments by Mark Muraven of the University at Albany and his colleagues have shown that after exertion, willpower has not entirely vanished. Rather the body seems to be conserving energy; if an important challenge or opportunity arises, more self-control can be tapped. This finding parallels what happens with physical muscles. As muscles begin to tire, athletes cut back on exertion to conserve remaining energy and strength. But they can marshal concerted effort if needed, calling on reserves for a sprint to the finish.

Muscles do not just become fatigued; they increase in strength when used regularly. Self-control can also strengthen with practice, as shown when people go through an exercise program to enhance it. In several studies, volunteers were assigned for a two-week period to change how they speak—avoiding curse words, using complete sentences, and saying "yes" and "no" instead of "yeah" or "nope." In another program, subjects were simply asked to improve their posture—sitting or standing up straight. After the exercises were completed, we evaluated the subjects' self-control using lab tests, such as squeezing a handgrip for as long as possible, but without any altering of speech or posture patterns. Those who had practiced the earlier exercises performed significantly better than a control group that had not had to clean up their language or sit up straight.

It has occurred to us from these studies that the Victorian notion of "building character" seems to have some scientific validity. Exerting self-control on a regular basis appears to build up a person's capacity to call on more of this character trait in a pinch.

When we did these studies, we began to ask ourselves whether actual physical energy was getting used up—or whether the notion of energy consumption was in fact just a psychological metaphor. An answer to this question came serendipitously when a failure in one experiment led to a new and useful insight.

Some scientists presumably march from one successful study to another, but I am not one of them. In this case, Matt Gailliot, then a graduate student, wondered whether we could extend the observation that willpower becomes depleted when someone resists temptation. What about the opposite case? Would indulging in temptation actually strengthen willpower?

I had my doubts, but I encouraged Gailliot to pursue the question, which we informally called the "Mardi Gras theory," in reference to the Christian tradition of indulging in sinful impulses in preparation for a period of self-denial during Lent.

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First we sapped people's self-control by requiring them to mentally suppress the forbidden thought of a white bear. Then we randomly assigned some of the participants to drink a delicious ice cream milk shake before they took a disguised test of willpower that consisted of searching a matrix of numbers for a particular sequence. In fact, the sequence was not there, and the goal was to see how long people could keep trying before they gave up.

The folks who drank the shake persevered longer on the test than those who got nothing. This apparent victory for the Mardi Gras theory was soon undercut by another result that involved an additional control group. One of the groups, as before, received nothing to drink before the test and, as expected, did badly on that test. The other group drank a milk shake that did not taste good; it contained unsweetened half-and-half rather than ice cream, so it was basically a large, unappetizing glass of dairy glop. Unfortunately for Gailliot's theory, the half-and-half group also did better than the unfed subjects. Gailliot was initially glum because the experiment seemed a bust. But as we talked, another thought occurred to us: If it was not the pleasure of indulgence that restored willpower, could it have been the calories?

We started reading up on glucose, the sugar in the bloodstream that provides energy to bodily tissues, including the brain, the seat of self-control. We ran a large series of studies and came up with two supportive findings that have stood the test of time. One showed that when blood glucose is low, self-control suffers, often substantially. This pattern, by the way, gives credence to the oft-heard complaint that a person is having difficulty functioning because of "low blood sugar"—a conclusion that also jibes with studies from nutritionists.

The other meaningful finding confirmed that a dose of glucose administered just before self-control is beginning to flag helps to restore the needed willpower to press ahead. These results strongly suggest that willpower is, indeed, more than a metaphor. Further, if exerting self-control diminishes willpower and the energy needed to sustain it, then the remaining energy can be conserved by cutting back on further demands for self-control.

A third result did not hold up. We found in one study that blood glucose levels drop during a task that requires self-control. Such a finding would be consistent with the idea that exerting willpower uses up glucose. But we could not replicate the pattern reliably in later tests. Some studies from other labs have shown, however, that the brain uses more glucose when exerting greater effort—which makes sense, after all, given that it is the brain that controls self-restraint.

A CHALLENGE TO OUR IDEAS

LIKE MANY SCIENTIFIC THEORIES, our muscle model of self-control has evolved as other researchers have gotten into the act. Some have tried to build on what we have done, and others have wanted to dismantle or challenge our work. These findings—and the debates they have engendered—have helped flesh out our understanding of self-control.

One contentious issue has been whether the brain really runs out of fuel for willpower. Like us, other investigators have confirmed that self-control is impaired when blood glucose is low, a physiological state that affects both body and brain. Some researchers have argued that the human body has extensive reserves of glucose that could be drawn on if an amount allotted to willpower got used up.

Compounding the skepticism over our notion of energy depletion, the brain's glucose consumption does not fluctuate much—still, it does change some. In prehistory, people might have faced a threat of running low on glucose, but few in industrial societies need to worry—certainly not the well-fed college students in our experiments who showed signs of ego depletion or impaired self-regulation.

NEW FINDINGS SUGGEST THAT ANY BRAIN CHANGES OCCURRING IN ADDICTS DO NOT LEAD TO A LOSS OF SELF-CONTROL. PEOPLE CAN OFTEN CHOOSE WHETHER TO GIVE IN TO A CRAVING OR RESIST.

All these points are well taken. It is possible, though, that exercise of self-control does not necessarily lead directly to the exhaustion of glucose and that when the body senses that available glucose is running low, it makes adjustments to direct the sugar to where it is needed most. In that case, we would still be correct in thinking that willpower is a precious resource—one that needs to be conserved. The simplistic view that ego depletion means that the brain exhausts its fuel supplies is not tenable, but it does seem likely that the urge to conserve a partly depleted resource is powerful and pervasive.

Another critique suggests that any willpower deficit can be overcome by just putting people with declining reserves into circumstances that cause them to call up additional resolve. Studies have shown that assigning people to a position of power and leadership—or even paying them to try harder—makes them continue to show good self-control even in situations where their energy should be depleted by prior exertion of willpower.

This research raises the possibility that willpower is all in your head. No resource is actually depleted, but people simply lose motivation to work hard. It can also mean that when willpower declines, you can still exert effective self-control if doing so is critical. Think of the chief executive who feels the responsibilities and pressures of leadership during a corporate crisis.

In a related criticism of our view, Veronika Job, then at Stanford University, and her colleagues, including Carol Dweck of Stanford, whose innovative theories they built on, have proposed that willpower is limitless and that a person with sufficient motivation can simply keep going. For these researchers, the idea of ego depletion is an illusion based on a false belief.

Our energy-allocation theory does not entirely disagree with the view that people can draw on spare resources for a time. If your willpower is slightly depleted, your body may naturally seek to conserve what remains—but you can still suck it up and perform well if the situation warrants. Tired athletes conserve

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their energy for the winnable points and the crucial, decisive moments. Ego-depleted people do the same with willpower.

In our own studies, we have found that people who believe in unlimited willpower tap into existing reserves to increase blood glucose levels when the sugar should have otherwise been depleted. The story, though, grows a little more complicated when examined closely.

A crucial test came when people were not just slightly depleted but continued exercising self-control until serious fatigue could no longer be ignored. Kathleen Vohs of the University of Minnesota, Sarah Ainsworth, one of my former graduate students and now at the University of North Florida, and others had shown that cash incentives or leadership responsibilities enable people to sustain self-control even when their willpower is depleted. But these various studies then initiated a grueling series of exercises, which showed that depletion worsened, and self-control started to diminish. Crucially, those who had been led to believe in unlimited willpower actually did worse than others. That belief had been helpful at first, but in the long run it backfired.

Self-control, it seems, can be maintained—but not indefinitely. After all, you do not get an infusion of glucose because you think willpower is unlimited or because you have been promoted to a managerial role. You just become more willing to spend from your reserves. Eventually a limit is reached. The illusion of endless self-control is tantamount to believing that a bank account has infinite funds. At the beginning, you may spend freely, but ultimately you seriously risk running out of money.

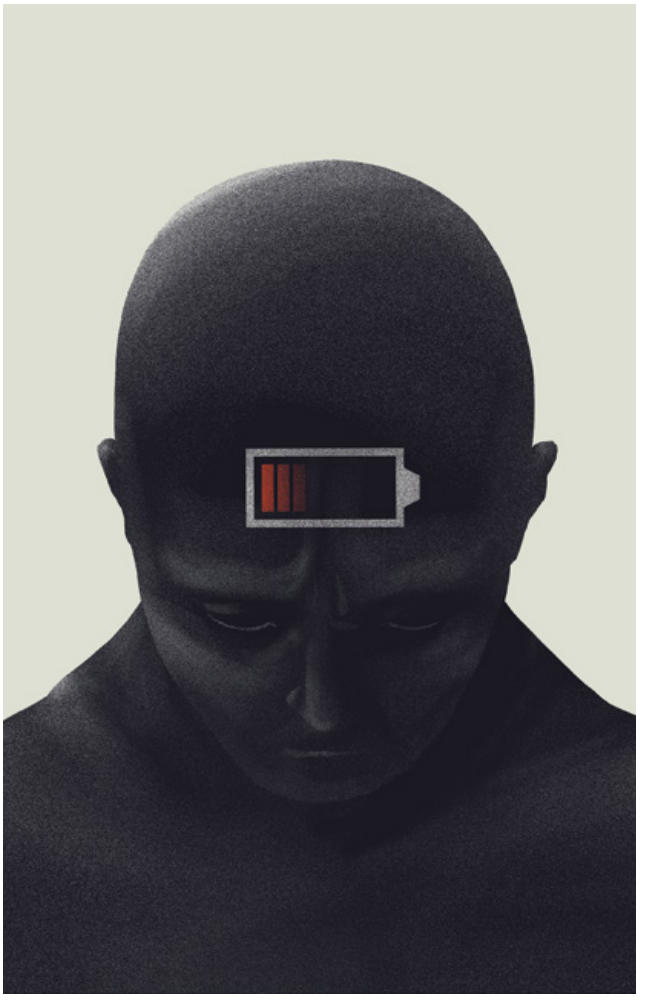
CAN YOU WILL AWAY AN ADDICTION?

RECENT STUDIES HAVE REVEALED newly discovered areas in which self-control plays a pivotal role. Some of these findings overturn prevailing ideas about various forms of addiction. A widely held view suggests that cravings for drugs, alcohol or cigarettes take over an addict's life and that quitting is impossible without complex medical treatments or at least a firm commitment to a 12-step-like program. Alan I. Leshner, former director of the National Institute on Drug Abuse and now CEO of the American Association for the Advancement of Science, has asserted that addiction is a "brain disease." As he put it, a user may take a puff or inject a substance voluntarily, but at some point, a switch in the brain is thrown. Substance abuse becomes involuntary, and the compulsion lingers even when the addict earnestly desires to quit. Willpower and volition disappear once addiction takes hold.

New findings indicate, however, that any brain changes occurring in addicts do not lead to a loss of control over one's actions; often these people have the power to choose whether to give in to a craving or resist.

More specifically, addiction does not bring about changes in a brain area essential for self-control that governs movement—that is, the motor cortex, where actions, whether brushing one's teeth or reaching for a crack pipe, are initiated. As addiction grows, the decision to grab the pipe does not suddenly become involuntary. Instead addiction brings on a slow and insidious change in desire. Heroin or cigarettes evoke pleasant feelings that develop into a longing for these substances.

The addict can resist for a time but gives in at some point, perhaps sooner rather than later, and must thwart the desire again and again. The desire is not always overwhelming, however. In a study by Wilhelm Hofmann, now at the University of Cologne in Germany, people were contacted at random throughout the week and asked to report on any desires that came to mind. Yearnings for cigarettes or alcohol were rated as weaker than any others.



This and other findings indicate that the addict experiences an intermittent stream of one mild urge after another. The frequently recurring nature of these urges is what makes quitting a challenge. But the addict is not beset by the mythically insurmountable difficulty of resisting an overwhelming desire.

The controversy about whether addicts are still in control will likely persist. Arguments from politicians, drug counselors and others help to sustain the myth that addiction is rooted in overwhelming, uncontrollable urges. Many addicts themselves favor this viewpoint because it exonerates them from personal responsibility. The media often promulgate these arguments, perhaps because actors and other celebrities who develop an addiction want to retain the love and loyalty of their fan base, an easier task if they can attribute their drug use to external demons and uncontrollable psychological drives. Fans might not be so forgiving if celebrities just admitted that they simply like taking drugs.

Psychologists differ as to whether self-control can be an ef-

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fective antiaddiction medicine. A survey in the U.K. found that addiction-treatment counselors who worked as volunteers tended to think that addicts can regulate their impulses. But those who received compensation for their work preferred to think that addicts are helpless and cannot get better without expert help. This argument is not intended to suggest that clinicians are in it only for the money. But when a controversy arises, financial incentives probably make it easier for people to endorse evidence that goes along with their own interests and to spot flaws in counterarguments.

Another addiction myth holds that cravings grow more acute only when quitting an addictive substance. A clever study by Michael Sayette of the University of Pittsburgh and his colleagues demonstrated that smokers believed that their desire would increase steadily over time, especially if they were told they could not light up.

The study also showed that these beliefs were wrong. Some participants had to abstain for a time and report their desire to smoke as part of the study protocol. Instead of the desire for a cigarette rising steadily, it went up and down unpredictably. Other studies have found that when a smoker quits, the desire to smoke goes down immediately and mostly stays in abeyance. If the addict relapses, as happens frequently, it is not because of an overwhelmingly strong urge for a cigarette. Rather it stems from a rather weak urge to light up at a moment when the smoker's willpower happens to have reached a nadir.

ADDICTION IS FOR THE STRONG-WILLED

THE IDEA THAT QUITTING an addiction requires willpower makes sense to most people. But until recently, few have considered that starting a drug habit and staying addicted also require self-control. Most of us do not really like the first taste of beer or the first puff of a cigarette. Public health warnings about their dangers can also dissuade indulging for the first time. Willpower, in fact, is needed to overcome those negative influences and take the first steps on the path toward addiction. To sustain an addiction over a long period, a user must expend a substantial amount of energy to ensure that a habit does not interfere with work, family and relationships.

Consider smoking. So many restrictions exist today that smokers need to craft elaborate plans to sneak a cigarette. When my former university introduced rules prohibiting professors from smoking in their offices, one colleague struggled heroically to comply. I will not soon forget the sight of her heading out of the building into a Cleveland snowstorm, while holding her tiny baby in her arms, on the way to light up.

Just think about how much self-control she had to muster. First, she had to plan when she would find breaks between classes, appointments and meetings—and where she would go to not violate campus smoking restrictions. Then she had to dress herself and the baby warmly. She also had to remember her cigarette pack and lighter on the way out into the storm.

A study on smoking conducted in the Netherlands by Michael Daly of the University of Stirling in Scotland, myself and our colleagues lends some credence to the anecdotal observation that maintaining an addiction requires good self-control. Daly's group found that a Dutch workplace ban that began in 2004 reduced smoking but with a couple of important qualifications. The ban lowered smoking mainly among people who rated themselves lower on a survey of self-discipline, and this group returned to its old habits within a few years. There was no apparent effect on people scoring high in self-discipline.

Scientists who favor the view that addicts have little self-control might have expected a different initial outcome—high self-control types would alter their behavior in response to the ban, whereas poor self-regulators would keep right on smoking. And they might explain the fact that we found the opposite result by reasoning that people with low self-control needed the strong push from the law to get them over the hump—and interpret the subsequent relapse by suggesting that over time the threat of a legal cudgel somehow faded.

But the explanation for the results appears to be related to the addicts' need to draw on reserves of willpower to preserve their habit. For years people had comfortably smoked right at their desks. Suddenly, that option was gone. To continue their habit after the ban, smokers had to make elaborate adjustments. Each break had to be arranged carefully to plan where and when it could happen.

People with good self-control could handle these demands. But those with low self-control gave up and quit for a while. Over time, however, they noticed the coping strategies of the self-controlling smokers. They saw, for instance, that these diehards headed outside to a particular "smoker's spot" in the park. They then simply copied those strategies.

A number of studies have shown that addicts seem able to consistently plan and execute intricate strategies to maintain heroin or cigarette habits—habits that researchers, clinicians and even users themselves once thought to be unshakable. These findings provide a new perspective on addiction. The possibility exists that these groups may be able to redirect the same sustained willfulness they use to procure a drink or fix toward kicking their habits. But this idea also raises a new set of issues.

A therapist may have difficulty convincing an addict that he or she has taken the wrong path if that person sees nothing permanently damaging with having a few drinks or popping painkillers while continuing to fulfill responsibilities at home and work. This new insight into the nature of addiction provides further evidence of the extent that self-control can influence our behaviors in myriad ways—and how it may even, perhaps counterintuitively, enable us to persist in adhering to self-destructive habits. It demonstrates, once again, that our ability to control our emotions and desires lets us manage, for good or bad, the endless challenge of adapting to the world around us. SA

Roy F. Baumeister is a social psychologist with research interests that range from social rejection to sexuality and aggression. He is a professor in the department of psychology at Florida State University.

MORE TO EXPLORE

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THE PURSUIT OF HAPPINESS

How to Control Your Feelings—and Live Happily Ever After

Learning to regulate powerful emotions can enhance physical and mental well-being

By Steve Ayan

ONCE UPON A TIME PEOPLE FIRMLY BELIEVED that thinking and feeling were two separate capacities, destined to often clash. As 17th-century Dutch philosopher Baruch de Spinoza put it, "When a man is prey to his emotions, he is not his own master, but lies at the mercy of fortune." By this logic, the intensity of experiences such as sadness, anger or fear can trump our reasoning. Yet modern research tells us otherwise. We are not slaves to our passing passions; rather we regulate emotions all of the time. You resist exploding at a client just because he is tardy, and you manage not to throw things at the house next door during their noisy barbecue. Controlling anger and frustration keeps our professional and private lives on track—and prevents irksome situations from escalating.

IN BRIEF

Psychologists recognize five different stages during which people can regulate their emotional responses to an event.
The best way to manage one's feelings depends on many factors, including how malleable the situation is and the intensity of our reaction to it.
Certain therapies can help individuals better manage otherwise innate responses.

Illustrations by Brown Bird Design

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Regulating emotions goes beyond keeping them down. We also need to find healthy outlets for our feelings. These inner responses, after all, can be excellent guides, as when fear warns you off a risky choice. They enrich daily life as well, leading us to revel in the joy of a birthday party or hoot ecstatically when a favorite team wins a game.

How exactly we go about striking a balance with our emotions is a topic that psychologists have been plumbing for decades. Their work has underscored that there is no single perfect approach. A good option in one case could be cataclysmic in another scenario. Instead we rely on dozens of techniques.

To make sense of these disparate tactics, psychologist James Gross of Stanford University developed a model in 1998 that sought to explain how emotions arise. Gross argued that any emotional experience follows a trajectory with five distinct stages in which a person can intervene to alter the outcome. At first we decide whether to seek out or avoid an emotional scenario. Then we may modify the situation itself. In the next two stages, we sideline unhelpful feelings by redirecting our attention or reappraising our response. Finally, we can deploy coping mechanisms to handle the physiological and behavioral consequences of an emotional event. The comprehensive scope and simplicity of Gross's model quickly made it the most influential framework for emotion regulation in the field.

The catch, however, is that most of our responses at each stage are automatic. How we react in the face of calamity is often the result of habit or circumstance rather than deliberate choice. "The learned set of emotion regulation [behaviors] is powerful and not easy to modify," says University of California, Berkeley, psychologist Iris Mauss.

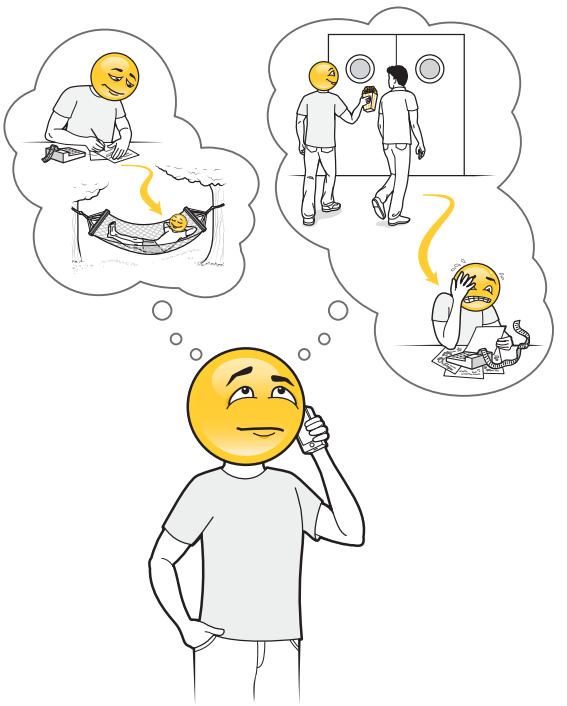
Yet we can learn complementary techniques to make the most of our knee-jerk responses. Current research has confirmed that with a little training and awareness, we can learn to avoid potential pitfalls and prevail over every part of this process. By heightening sensitivity to long-term goals, the broader context of an event and a feeling's intensity, we can make smart choices in even fraught situations. In short, we can master our emotions.

Steve Ayan is a psychologist based in Heidelberg, Germany, and is an editor at *Gehirn & Geist*.

B E A B E T T E R Y O U

STAGE 1

Pick and Choose



It is a rainy Friday afternoon. You have had an exhausting week, and you want nothing more than to curl up on the couch and take a nap. You had planned to spend a long, lonely evening working on your taxes. Then a friend calls to ask if you want to see a movie instead.

You are facing the very first stage in Gross's model: "situation selection." You have the power to choose the path your evening will take and the emotional outcome of your day. Here you have to engage in some psychological fortune-telling. How might an evening of taxes make you feel in the future? If you see the movie instead, how will your Saturday shape up? This task can be challenging. Spending time with a friend may be restorative—or it might lead you to neglect necessary chores.

Before you decide, bear in mind that people routinely overestimate the intensity of future emotions. Numerous studies have shown that negative outcomes are often not as bad as we expect, and sometimes pursuing a seemingly more positive option can inadvertently set us up for disappointment. For example, in findings published in 2011 Mauss and several colleagues asked 69 participants to read either an article extolling the value of happiness or an emotionally neutral story. Afterward the participants watched a feel-good film clip. Curiously, the people who had read about the benefits of happiness felt less cheery after the movie than the participants who had not read the article. Why the paradox? Mauss theorizes that a preoccupation with being happy can lead people to expect too much from everyday pleasures. Additionally, evaluating your level of bliss may heighten self-awareness, which could hinder the experience of pleasure when it comes your way.

Psychologist Maya Tamir of the Hebrew University of Jerusalem has found that rather than making the pursuit of happiness a guiding principle in life, a person should think in terms of broader aims. In 2012 Tamir and Brett Q. Ford, now at the University of Toronto, gave 136 people a battery of tests, including one designed to assess emotional intelligence, which is the ability to recognize, control and express emotions. The participants pondered situations and selected the emotion they would prefer to experience in that moment. For example, "If you need to reach a compromise, would you rather feel angry or happy?"

Tamir and Ford found that people with high emotional intelligence opted for whichever feeling had greatest utility—regardless of whether that emotion was pleasant. A little anger might help an otherwise easygoing person prepare for a difficult negotiation, and piquing anxiety could create extra incentive to study for an exam. A good policy, then, is to keep your long-term goals in mind when evaluating a decision such as how to spend your Friday evening.

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STAGE 2

Take Action

Often people face an emotional event with no way to change course. Perhaps they have to read a eulogy at a funeral or sit next to a particularly irksome aunt during a holiday meal. In these cases, the best options involve "situation modification," or changing elements of the environment to make things easier.

The key is to anticipate the potential for stress and take proactive measures. These interventions can be as simple as carrying a lucky charm to make you feel more comfortable or asking a friend to sit nearby as a conversational buffer. Such strategies can also avert further annoyance. For example, if a neighbor is making a lot of noise, you may be better served asking him to quiet down now rather than waiting it out and becoming more frustrated.

Recent research suggests that people who do not take steps to ease difficult circumstances will only compound their troubles. In 2013 Franklin & Marshall College psychologist Allison S. Troy, along with Mauss and New York University mindfulness researcher Amanda Shallcross, recruited 170 volunteers who had experienced a challenging life event in the two months prior to the study. The experimenters first rated how controllable these events were—ranging from accidents and illnesses that no one could have foreseen to things caused directly by the individual's actions, such as losing a job because of poor performance. Next, the volunteers watched a sad movie while consciously trying to view the film in a positive light.

Some people found this task to be more taxing than others did. Among the participants who were very successful in reframing the film, those whose recent history had included a stressful but controllable event, such as getting fired because of shoddy work, reported more symptoms of depression than counterparts whose experiences had been less controllable. Events that could have been averted left people more susceptible to depression, perhaps because their failure to prevent problems primed them for feelings of hopelessness. And people who could recast a negative event in a positive way may be most at risk because their flexible thinking allows them to recognize different outcomes to their earlier life events. Individuals in controllable scenarios, therefore, should identify and address sources of stress proactively rather than assuming they can manage the emotional fallout later.

ANTICIPATE POTENTIAL STRESS AND TAKE PROACTIVE MEASURES, SUCH AS ASKING A FRIEND TO BE AN EMOTIONAL BUFFER.

Five Tips for Emotional Health

Emotions are hard to control. But even without a fully fledged strategy for regulation, you can adopt some basic techniques to improve your well-being:

Be active. Physical exercise and intellectual engagement usually prevent people from focusing on negative emotions too much. Strain your body once in a while at the gym or enjoy good food, books and music. Such pastimes can make it easier to look at the bright side of life.

Try new habits. Disrupting your routine can help you focus on positive events and avoid boredom. For example, start a diary and take note of nice things that happen to you. Reserve a few minutes each day to remind yourself of happy times.

Be social. Mingle with folks you like. An active social life is an effective means to overcome everyday worries and mild anxieties.

Be thankful. Being grateful for what you have received enhances satisfaction.

Don't set the bar too high. It is possible to want happiness too much. Putting pressure on yourself to be merry all of the time may itself become a source of discontent. It is okay—and healthy—to experience a whole spectrum of emotions.

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STAGE 3

Look Elsewhere

When it is too late to change any aspect of a situation, Gross proposed that people deploy their attention to their advantage, either through distraction or through focus on the matter at hand. For instance, if you need to keep a serious demeanor during an important professional meeting, you might avoid glancing at a colleague who enjoys clowning around during work hours.

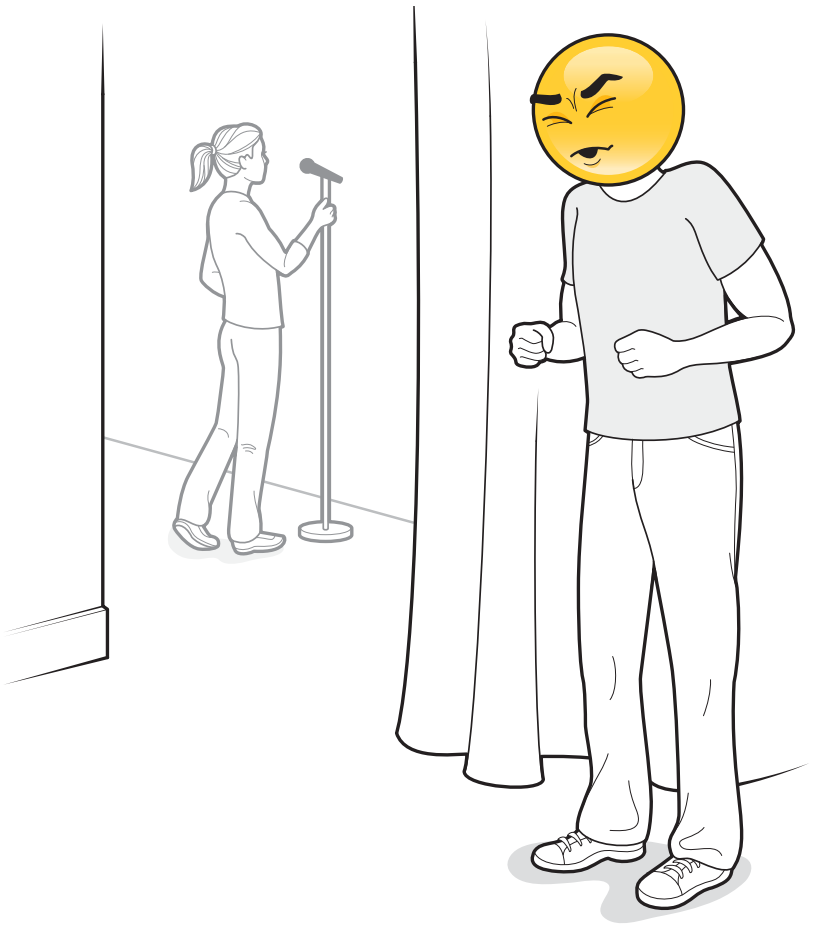
Whether you should concentrate your attention or divert it will depend in part on the situation's intensity. In a series of studies, psychologist Gal Sheppes of Tel Aviv Univer-

STAGE 4

Think Again

The people in Sheppes's 2014 study who did not look away from disturbing photographs engaged in a process that psychologists call "cognitive change" or reappraisal. This is when individuals tackle thoughts that lead to an emotional response. For example, a performer with stage fright might reframe nervous energy as "getting pumped" for his next show.

In its most extreme form, some people engage in this stage through prolonged pondering of their personal experiences and sensations. This practice, known as rumination, can intensify symptoms of depression and aggression. A better technique, according to psychologists Ethan Kross of the University of Michigan and Ozlem Ayduk of U.C. Berkeley, is "self-distancing," or imagining the situation as an impartial observer. Instead of asking "Why do I feel like that?" they recommend addressing the question in the third person: "Why does Steve feel like that?"



In 2012 Kross, working with colleagues at Ohio State University and VU University in the Netherlands, published findings from a study in which they examined how self-distancing strategies affect feelings and behaviors. In the first experiment they asked 94 volunteers to rapidly solve anagram puzzles and then announce their solutions aloud. The experimenters, meanwhile, stoked the students' ire by repeatedly demanding that the speaker raise his or her voice. After this activity the students had to visualize the events that had just taken place in one of three ways: as they themselves experienced them, as though they had been a mere witness to the events, or without any special instructions.

Kross and his colleagues found that the participants who imagined the events as though they had been bystanders harbored significantly fewer aggressive thoughts and feelings than their colleagues who had relived the preceding moments. In a follow-up experiment, students who used this fly-on-the-wall perspective for thinking about an emotional moment showed less aggressive behavior than their peers who had not employed self-distancing.

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sity asked participants to either reinterpret a sad photograph in a way that made it less worrisome—seeing tears of joy as opposed to grief, for example—or think of something completely different. Although people who reimagined an image's meaning could alter their emotional response, participants often opted for avoidance. Sheppes found that the more unsettling an image was, the more often people preferred to self-distract. This result suggests that attending to a powerful stimulus can be exhausting, making the opportunity to look away a welcome relief.

In 2014 Sheppes took these findings a step further. He asked 22 participants to look at photographs with varying emotional intensities. This time, however, he gave them additional information. He instructed some of the subjects to respond in a way that would minimize their immediate negative feelings and told other participants that they would have to confront this image later in the experiment. Once again, most people looked away when an image was especially distressing, but those who believed they would view the image in the future were more likely to study even the intense pictures. Distraction, therefore, is an easy option but not necessarily the best way to respond to a recurring concern.

Admittedly, controlling attention can be a challenge: our thoughts and gaze often wander despite our best efforts. Yet certain therapies might help. For example, working memory training, which bolsters the brain's ability to hold and manipulate multiple pieces of information, can boost many facets of emotion regulation, including attention. Typically this training involves learning memory strategies, such as mental rehearsal and mnemonic devices, and doing exercises that use working memory. In addition, mindfulness-based stress-reduction therapy can teach practitioners to observe and detach from inner reactions to strengthen emotional management. In 2010 Gross and Philippe Goldin, now at the University of California, Davis, found that eight sessions of this therapy and a half-day meditation retreat could help people with social anxiety disorder learn to attend to their breathing to refocus during an unpleasant experience.

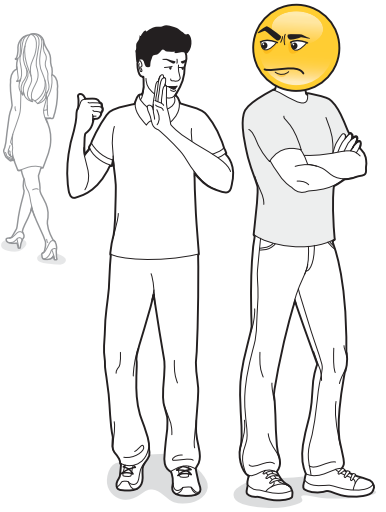
STAGE 5

Let It Out

But what if, despite your best efforts, you still find yourself walloped by an emotional blow? If someone unexpectedly shares an insulting opinion, for example, you might not be able to avoid feeling hurt, but you can still respond in many ways. Your jaw might drop in indignation, you could take a deep breath to calm your rising pulse, or you might smile and act unfazed. In the final stage of regulation your options are limited to managing your bodily response.

A person's immediate reaction may be dictated by personality, experience or culture. For example, many Western societies advocate venting, or the release of stress through conversation or exercise. Unfortunately, these techniques can sometimes fuel a person's fury further, revving up energy instead of releasing it.

The primary strategy that people employ at this stage is suppressing their physical reactions. This response results in part from parents raising their children to behave in this way. Not screaming, hitting or crying whenever you feel like it is an integral part of socialization—but holding back emotions can take a toll. In a classic experiment, psychologist Roy F. Baumeister of Florida State University found that when people restrained their emotions during either a comical or sad film clip they tended to give up earlier on a subsequent anagram puzzle than participants who could express their feelings. Resisting emotional responses had taxed their willpower and energy.



This stress and exhaustion could explain why inhibited expression of feelings is linked to health problems. Johan Denollet and his colleagues at Tilburg University in the Netherlands found in 2010 that people who regularly suppress their emotional distress—a pattern called type D personality—have an increased risk of cardiovascular disease. Denollet has also found that those who hold back emotions suffer more from chronic pain, tinnitus and diabetes than the general population.

Suppression can also put your relationships at risk, as psychologist Emily Impett of the University of Toronto and her colleagues discovered in a 2012 study. In a survey of 80 couples, Impett learned that men and women felt emotionally distanced when they discovered that their significant other had not disclosed his or her feelings in the past. In a follow-up three months later the researchers found that "suppressor couples" had worse-functioning partnerships than other participants.

In addition, a host of studies make it evident that positive feelings are far easier to squash than negative ones. Restraining your response—whether smiling in spite of your sadness or holding back an inappropriate giggle—is ultimately a powerful strategy that should be used sparingly.

The lessons from suppression research are an important reminder that regulating emotions need not mean avoiding them. Instead people can learn to better anticipate their own reactions to intense moments, visualize the outcomes they would prefer and identify the actions that could change those future feelings. By acknowledging and exploring why we feel a certain way, we can use both happy and troubling events to our advantage. They may even prompt us to dig into our beliefs, experiences and misconceptions—and discover new insights into ourselves.

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THE PURSUIT OF HAPPINESS

THE SELF-COMPASSION SOLUTION

Building on a Buddhist principle, psychologists are learning how being kind to yourself can bolster resilience, buffer against stress and improve relationships

By Marina Krakovsky

Illustrations by Marina Muun

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A FEW YEARS AGO THEN 28-YEAR-OLD MICHELLE RAPP, A CORNELL UNIVERSITY graduate, experienced a series of unfortunate events. First, she lost her job in a mass layoff at a San Francisco start-up. Then, anxious to get back to work, she took a physically demanding job at a Chinatown tea shop—but weeks later she threw out her hip while carrying boxes up the store's steps. Unable to walk and go on job interviews and feeling stressed and demoralized, she immersed herself in a cerebral and competitive card game, Magic: The Gathering. Yet even this diversion ended up causing anguish for Rapp. Her whole-hog approach to the game—joining tournaments and founding a local chapter—was only the latest act in a lifelong pattern of setting ambitious goals and then judging herself harshly for failing to meet them.

When she found herself on a losing streak, she could not stop beating herself up. "Looking back, it seems crazy," Rapp says. "Of course, I'm a good player. Yet I couldn't forgive myself for losing."

Rapp believes this self-destructive behavior stems from growing up with intense parental pressure to excel—pressure, she says, that often took the form of emotional and physical abuse. In recent years she has undergone treatment for anxiety and depression—but in her case, it was not therapy that broke her self-defeating pattern. Talking with her husband about her problems reminded Rapp of a book she had read on nonviolent communication that emphasized the importance of speaking with compassion—including compassion for yourself. That recollection was Rapp's aha moment.

Self-compassion, at its most basic level, means treating yourself with the same kindness and understanding that you would a friend. People who struggle with this concept, research shows, do not necessarily lack compassion toward others. Rather they hold themselves to higher standards than they would expect of anyone else. Developing self-compassion allows them to recognize and accept their own feelings rather than constantly challenging themselves to "do better."

Rapp is one of a growing number of people to discover that practicing self-compassion can be a surprisingly effective alternative to the crippling yet common habit of shame-laden self-criticism. Since the birth of self-compassion as a scientific construct—with the publication of a seminal paper by psychologist Kristin D. Neff of the University of Texas at Austin in 2003—the volume of academic publications investigating self-compassion has snowballed.

In the past few years self-compassion has gone mainstream, as some of its researchers and practitioners—including Neff—have written books and created workshops to popularize the concept. Untold numbers of life coaches, mindfulness teachers and psychotherapists now tout the benefits of self-compassion. Psychotherapists see it as a natural component of well-studied therapies that focus on accepting and gradually changing unhelpful thoughts or behavior patterns, such as cognitive-behavioral therapy and accept-

IN BRIEF

Inspired by Buddhist practices, self-compassion involves treating oneself with the same kindness and understanding that someone would offer a friend.

This trait has been found to increase motivation required to persist in a task after failure and seems to enhance resilience to challenging or traumatic events.

By caring for themselves, individuals can also be more present in relationships and can sustain greater compassion for others.

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ance and commitment therapy.

Yet many people resist self-compassion, fretting that being compassionate toward ourselves will make us egocentric, self-indulgent or weak. If we are easy on ourselves after a setback, we wonder, will we turn soft and complacent? This question is one of many self-compassion research has tried to answer. The conclusion: a resounding "no." As mounting evidence shows, self-compassion is typically a source of both personal and interpersonal strength, making self-compassionate individuals more emotionally stable, more motivated to improve themselves and generally better to be with.

BUDDHIST ROOTS

NEFF, THE PIONEER in the scientific study of self-compassion, became interested in the topic in the 1990s. As a Ph.D. candidate struggling with the breakup of her first marriage, she was full of shame and self-loathing. She began attending meditation classes and exploring Buddhist thought.

Neff knew that compassion entails concern with another's pain and a desire to alleviate that person's suffering, but she had never thought about directing that energy toward herself until she read Buddhist teacher Sharon Salzberg's book *Lovingkindness*. She felt transformed by its message that showing kindness to oneself is essential for showing genuine love toward others. She soon began to lay the groundwork to study self-compassion scientifically.

Through her reading, Neff discerned three indispensable elements of self-compassion: kindness toward yourself in difficult times, paying attention to your suffering in a mindful, nonobsessive way, and common humanity, or the recognition that your suffering is part of the human experience rather than unique to you. These three components (along with their opposites) became the basis of the questions Neff used to develop a self-compassion scale [*see top box on next page*], an instrument she published in 2003 in the journal *Self and Identity* that is now widely used by other researchers in assessing a person's level of this trait.

Using this scale, Neff has shown that self-compassion correlates with important real-world outcomes. In particular, she found that people who score high in self-compassion are less prone to anxiety and depression.

Psychologist Juliana Breines first encountered Neff's work while she was an undergraduate at the University of Michigan. Breines suspected self-compassion could help people get off the roller coaster of "contingent self-esteem"—that is, the problem of tying your evaluation of yourself to fluctuating factors such as academic achievement and others' approval. Many studies have demonstrated that this kind of thinking is not conducive to mental health or learning. But Breines worried self-compassion might also undermine motivation. As she puts it, "Self-compassion might be comforting, but does it let you off the hook too easily?"

Breines tested this question a few years later, as a graduate student at the University of California, Berkeley. In one of a series of experiments, she and her colleagues had 86 undergraduates take a tough vocabulary quiz. To see the effect of self-compassion on study behavior, they told one group that it was common to find the test difficult and urged subjects not to be too hard on themselves. A second group got a self-esteem message instead: "Try not to feel bad about yourself—you must be intelligent if you got into Berkeley." A third group received no additional statements.

Then the researchers measured how long the undergrads would study for a second, similar test. As they reported in 2012 in *Personality and Social Psychology Bulletin,* the self-compassion group went on to spend 33 percent more time studying for the subsequent quiz than the self-esteem group and 51 percent longer than the neutral control group—a sign that self-compassion bolsters motivation. Being kind to yourself can make it safe to fail, which encourages you to try again.

In a pair of 2012 studies led by social psychologist Ashley Batts Allen, then at Duke University, researchers investigating self-compassion in older adults found both psychological and practical benefits. In the first study, with 132 participants ranging from 67 to 90 years old, they found that people who were strongly self-compassionate reported a greater sense of well-being even when they were in poor health. In the second study, involving 71 seniors, self-compassion predicted how likely they were to be willing to use a walker if necessary. "The self-compassionate people were just less bothered by the fact that they needed help," explains Allen, now at the University of North Carolina at Pembroke.

Mark Leary, a Duke psychologist who collaborated with Allen, adds that if you are low in self-compassion, "you're using too much emotional energy thinking about the bad feelings" and not enough addressing the real issues. For example, denying one problem—insisting on not using a walker—can create further difficulties, such as a hip fracture. The mindfulness component of high self-compassion, in contrast, leads people to acknowledge and accept reality, without an emotional judgment. The common-humanity component helps,

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too, by, for example, allowing one to recognize that everyone has physical limitations with age.

In 2014 Leary and his colleagues studied 187 mainly African-American people living with HIV. Patients who were higher in self-compassion showed healthier reactions to life with the potentially deadly virus: they experienced less stress, felt less shame about their condition, and were more likely to express a willingness to disclose their HIV status and to adhere to medical treatment. And a 2015 meta-analysis of 15 studies with a total of 3,252 participants, published in *Health Psychology,* found links between self-compassion and health-promoting behaviors related to eating, exercise, sleep and stress management.

BOUNCING BACK TO NORMAL

RESEARCH INDICATES that the self-compassionate are more psychologically resilient and better able to regain emotional well-being after adversity. People who used self-compassionate language after their divorce, for example, recovered more quickly than those who had a more self-critical or self-pitying ("Why me?") outlook on the relationship's failure, according to a 2012 study of 109 adults.

Caregivers, too, can benefit. Raising an autistic child, for instance, is more emotionally difficult than other forms of parenting, with levels of stress and hopelessness that tend to correspond to the severity of the child's symptoms. Yet a 2015 study of 51 parents of autistic children found that those mothers' and fathers' self-compassion was more important than the severity of the child's symptoms in predicting a caregiver's well-being.

Yet another example comes from 115 combat veterans of the wars in Iraq and Afghanistan. In a 2015 study in the *Journal of Traumatic Stress,* self-compassionate war veterans experienced much less severe post-traumatic stress disorder (PTSD) symptoms than those lower in self-compassion, even after accounting for the level of combat exposure. "It's a powerful testament to the idea that it's not *what* you face in life," Neff says, "it's how you relate to yourself when you face very hard times."

Recent studies of people with other psychiatric disorders, including binge eating and borderline personality disorder, suggest that self-compassion helps recovery. Allison Kelly, a psychologist at the University of Waterloo in Ontario, who has studied the effect of a self-compassion intervention on binge-eating disorder, points out that recovery requires not only learning to tolerate urges to binge but also figuring out how to bounce back after giving in to those urges. "If, like a drill-sergeant coach or critical teacher, you're threatening yourself into change and beating yourself up whenever you slip up, it makes it hard to feel calm and confident," Kelly says, "and often takes away the ability to reflect and learn from what you're going through."

Self-compassion might seem to go hand in hand with self-esteem. In fact, self-compassion can coexist with low self-esteem and can buffer against it. In a 2015 longitudinal study led by Sarah Marshall, a psychologist at Australian Catholic University, researchers tracked a group of 2,448 students as they moved from ninth to 10th grade. Marshall found that high self-esteem was a precursor to good mental health, regardless of the students' level of self-compassion. But self-compassionate kids who had low self-esteem *also* showed good mental health.

That news is good because it is usually easier to raise someone's self-compassion than his or her self-esteem, Duke's Leary says. "It's really hard to get someone with low self-esteem to like themselves until they develop more social skills or get a better job or something." By comparison, the bad habits of low self-compassion, such as denying a problem exists or beating yourself up, are easier to break.

STRONGER RELATIONSHIPS

RECENT RESEARCH SUGGESTS that self-compassion is also good for relationships. Neff led a 2013 study of 104 couples that looked at how self-compassionate people treat their romantic partner—as rated by that partner. In general, men and women who scored high in self-com-

Do You Have Self-Compassion?

The statements below are from an assessment created by psychologist Kristin D. Neff. In the full version (http://bit.ly/SlfCompassion), you would rate yourself on a scale of 1 to 5, where 1 is "almost never" and 5 is "almost always."

Statements associated with high self-compassion:

- I try to see my failings as part of the human condition.
- When I'm going through a very hard time, I try to keep my emotions in balance.
- I try to be understanding and patient toward those aspects of my personality that I don't like.

Statements linked to low self-compassion:

- When I fail at something important to me, I become consumed by feelings of inadequacy.
- When I'm feeling down, I tend to feel like most other people are probably happier than I am.
- I'm disapproving and judgmental about my own flaws and inadequacies.

Give Yourself a Break

Expert tips for cultivating self-compassion:

- Realize that self-flagellation does not help you reach your goals but actually holds you back.
- If self-compassion scares you, perhaps because of past abuse, consider turning to a counselor trained in compassion-focused therapy.
- If you are a parent or teacher, strike a balance between celebrating children's achievements and helping them understand that struggles are normal, too.
- Everyone is different, so explore which self-compassion practices work for you. (You can find specific exercises on psychologist Kristin D. Neff's Web site: http://self-compassion.org/category/exercises)

If you are struggling with self-compassion exercises, be patient and forgiving with yourself—even if that means *not* practicing self-compassion. —*M.K.*

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passion were seen as more caring and supportive (and less controlling and verbally aggressive) than individuals low in self-compassion.

Yet Neff has also found that most people have an easier time being compassionate to others than to themselves. A striking illustration is another 2013 study in which she measured both self-compassion and self-reported compassion for others among 384 college students. Neff found absolutely no correlation between the two forms of compassion; similar studies of practicing meditators and of ordinary adults showed only weak correlations. She has also noticed that practitioners of Buddhist metta, or loving-kindness, meditation—in which you start by wishing yourself well and go on to extend your goodwill toward an increasingly widening circle of empathy—give short shrift to the beginning section. Instead they focus on kindness to others.

But if people find it easier to show compassion to others than to themselves, how can we understand the results from the couples study? Neff believes that being kinder to others than to yourself, though possible, will not carry people through long-term relationships. "If you give your all to your partner and are hard on yourself, you can't sustain a healthy relationship," she says.

This interpretation dovetails with findings, published in 2013 in *Self and Identity,* that revealed how self-compassionate people handle interpersonal conflicts. The study, led by applied statistician Lisa Yarnell, involved 506 undergraduates. Yarnell, now at the American Institutes for Research, found that students high in self-compassion were better at balancing the needs of themselves and of others and felt better about a conflict's resolution than those low in self-compassion. The self-compassionate individuals reported lower levels of emotional turmoil and greater relational well-being.

These findings have implications for full-time caregivers, who have long been known to be at risk for burnout and "compassion fatigue," a deadening of compassion through overuse. In fact, a 2016 cross-sectional survey study of 280 registered nurses in Portugal suggested that although nurses with higher levels of empathy were at greater risk of compassion fatigue, empathy was not a risk factor if it was accompanied by self-compassion.

TEACHING SELF-COMPASSION

IF BEING SELF-COMPASSIONATE has so many positive outcomes, can people learn to treat themselves more kindly? One promising intervention is mindful self-compassion, or MSC, an eight-week workshop that Neff developed with Christopher Germer, a clinical psychologist who teaches part-time at Harvard Medical School. The MSC program, designed for the general public, explains the research on self-compassion and introduces a variety of exercises, such as savoring pleasant experiences, touching yourself soothingly, using a warm and gentle voice, and writing a letter to yourself from a loving imaginary friend.

In a small study published in 2013, Neff and Germer reported that 25 people (mainly middle-aged women) who completed an MSC workshop reported higher gains in self-compassion and well-being than a similar group randomly assigned to the wait list for the workshop. Furthermore, the workshop participants maintained their gains a year later. Interestingly, people in the control group also showed some gains in self-compassion—the control group's self-compassion scores rose 6.5 percent between the pretest and the post-test phases, whereas the experimental group's self-compassion scores rose 42.6 percent. This result initially puzzled the researchers—until they discovered that the wait-listed group used the time to learn about self-compassion independently through books and Web sites.

It remains unclear how much the MSC participants' success is related to the training itself as opposed to, say, being in a group or having caring teachers, notes Julieta Galante, a research associate in psychiatry at the University of Cambridge. In 2016 Galante and her colleagues published the results of an online, four-week randomized controlled study of only the loving-kindness meditation—an exercise often used to cultivate compassion for yourself and others but not targeted specifically to relieve suffering. The team found no difference between the meditation group and a control group doing light physical exercise.

Furthermore, many people dropped out of the intervention, some actually describing intense, troubling emotions—crying uncontrollably or realizing they had no uncomplicated relationships in their lives. Germer and Neff brace their workshop participants for this possibility, using the firefighting metaphor of "back draft" to explain the phenomenon: just as flames rush out of a room as oxygen returns, old pain can surface amid an influx of compassion in people starved of love. It is possible that before taking a course, some individuals may need to ease into self-compassion practice slowly, perhaps with the aid of a therapist.

Paul Gilbert, a professor of clinical psychology at the University of Derby in England, agrees. In his years of treating victims of childhood abuse or neglect, he has observed that kindness can backfire. Anything that stimulates fragile attachment systems can trigger memories of past trauma, particularly in cases of childhood abuse. "There are so many fears and resistances to compassion that it would just blow fuses" to start with exercises for the general public, Gilbert says.

The compassion-focused therapy that he developed for such patients and tested through small-scale studies starts with psychoeducation and proceeds gradually. Gilbert explains to patients, for example, that self-criticism is not their fault and shows how it may have developed as a way to protect themselves from threatening parents. Once patients understand that neither their genes nor their early environment is their fault, they can begin to let go of shame—and start taking responsibility for their future.

That is what Michelle Rapp did. Although she came to practice self-compassion independently, earlier therapy likely laid the groundwork for her journey. She eventually came to accept her injury and other setbacks and overcame the shame she had often felt in asking for help. During her recovery, she stopped forcing herself to hobble to a bus stop on crutches and sprung for a cab. She knew she was worth it. SA

Marina Krakovsky writes and speaks about the practical wisdom of the social sciences. Her most recent book is *The Middleman Economy: How Brokers, Agents, Dealers, and Everyday Matchmakers Create Value and Profit* (Palgrave Macmillan, 2015).

MORE TO EXPLORE

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THE PURSUIT OF HAPPINESS

BE A BETTER YOU

BEING IN THE NOW

A focus on the present, dubbed "mindfulness," can make you happier and healthier. Training to deepen your immersion in the moment works by improving attention

By Amishi P. Jha

Photo Illustration by Aaron Goodman

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PULLING INTO A PARKING SPOT AT WORK, YOU REALIZE YOU HAVE NO RECOLlection of the drive that got you there. On reaching the bottom of a page in a book, you are frustrated that you have failed to understand what you just read. In midconversation, you suddenly become aware that you have no idea what the person speaking to you has just said.

These episodes are symptoms of a distracted mind. You were thinking about a vacation while reading a report or reliving an argument with a friend instead of paying attention to the road. Whether the mind journeys to the future or the past, whether the thoughts that whisked you away were useful, pleasant or uncomfortable, the consequences are the same. You missed the present, the experience of the moment, as it was unfolding. Your mind was hijacked into mental time travel.

Distinct from deliberate daydreaming, our mind gets offtrack in this fashion almost half the time, according to studies in which people report by smartphone what they are doing, feeling and thinking throughout the day. Mental meandering away from the task at hand, referred to as mind wandering, is tied to negative mood. Chronic psychological stress, suffered by millions, is built on a mind consumed by rumination, worry or fear about many topics. This type of diffused and unstable focus impairs performance, too. In moments that demand quick decisions and action, the consequences of diverted attention and perception could be deadly.

The opposite of a wandering mind is a mindful one. Mindfulness is a mental mode of being engaged in the present moment without evaluating or emotionally reacting to it. Thou-

IN BRIEF

Mindfulness is a mental mode of paying attention to our present-moment experience without evaluating or emotionally reacting to it.

More than 250 medical centers worldwide now offer mindfulness-based programs to alleviate mood and other disorders and to improve well-being.

Mindfulness training works, at least in part, by strengthening the brain's ability to pay attention. This is often done by focusing on the breath.

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1

MODERN MINDFULNESS practices have their roots in customs that have been integral to Eastern cultures for millennia.

2

LEARNING to be more mindful, or aware of what is happening now, is an antidote to rumination, worry and fear—and their effects on mental health.

sands of articles lay out evidence showing that training to become more mindful reduces psychological stress and improves both mental and physical health, alleviating depression, anxiety, loneliness and chronic pain [*see box on page 60 for a sample exercise*]. Many workplaces and medical centers now offer mindfulness-based programs to improve well-being.

Findings from my laboratory and others have revealed a surprising mechanism for these benefits. Mindfulness training works, at least in part, by strengthening the brain's ability to pay attention. Although video games and medication may also sharpen focus, mindfulness training uniquely builds the ability to direct attention at will through the sea of internal and external stimulation while allowing for greater awareness of what is happening in the moment.

Whether research findings in small groups of individuals can be scaled up to society at large remains to be seen. The scientific literature on mindfulness training is still in its infancy, and many scientists are calling for more rigorous research methods, such as standardizing programs and placebo-controlled designs. Yet the promise of mindfulness continues to generate much interest. The overarching message seems to be that the more people engage in such training, the happier and healthier we all will be.

SALVE FOR SADNESS

EASTERN CULTURES have proffered various forms of meditation as a solution to the conundrum of human suffering. Ancient texts detail precise training exercises to cultivate specific mental qualities. One form of meditation, which we now call mindfulness meditation, instructs practitioners to pay attention to ongoing perceptual experience rather than conceptual trains of thought. People have been engaging in mindfulness exercises for millennia, claiming improved mental clarity and calm—and even greater longevity.

One broad category, referred to as focused-attention practices, guides individuals to select a specific sensation, tied to breathing for example, on which to focus. Instructions encourage the practitioner to notice when his or her mind goes astray and simply return attention back to his or her immediate sensations. Another type, called receptive or open-monitoring practices, coaches participants to watch what enters, then drops out of conscious awareness moment by moment. Think of hearing the faint sound of a fire truck siren in the distance. The sound becomes louder as the truck approaches, then faint-

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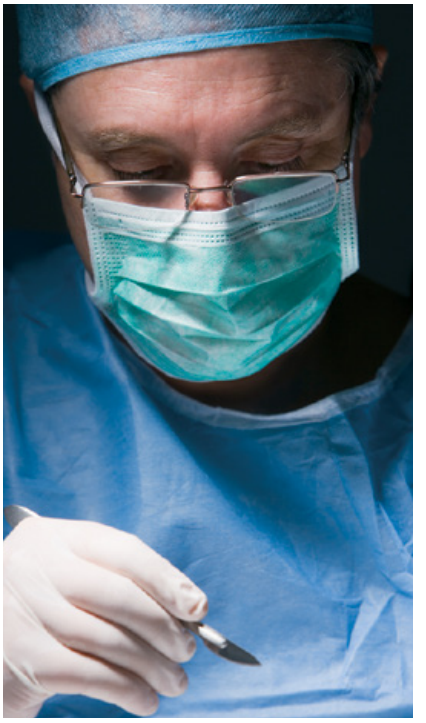
er again as it passes. You may notice that initially the siren is part of a vast sea of sounds, later that it is the most salient sound, only to fade into the background again. Thoughts, emotions and other sensations may similarly grow and diminish as we remain in a watchful monitoring mode. Many sages, beginning with Buddha Siddhartha Gautama, have advocated repeated engagement in these forms of meditation as a route to increasing mindfulness in daily life.

It was not until the late 1970s that research on mindfulness began to get traction in the psychological and medical sciences. At that time, biologist Jon Kabat-Zinn of the University of Massachusetts Medical School developed a secular outpatient program called Mindfulness-Based Stress Reduction (MBSR). The eight-week program emphasizes two aspects of attention: the ability to voluntarily focus attention, narrowing our thoughts to keep out distractions, and to monitor ongoing thoughts, feelings and sensations—without getting caught up in them—a phenomenon called meta-awareness. Working together, focusing and monitoring prevent our mind from wandering without our knowledge and escaping our control.



BY IMPROVING the ability to direct and monitor attention, mindfulness meditation could enhance people's performance in pursuits as diverse as sports and surgery.

In the past decade researchers have established that MBSR and similar techniques can be used to successfully treat a wide variety of illnesses. Mindfulness-based cognitive therapy, developed by psychologist Zindel V. Segal of the University of Toronto and his colleagues, is modeled after MBSR but emphasizes the idea that the negative thoughts that can spark a depressive episode are fleeting mental events. Their transitory nature means that patients can choose to pay attention to them or not. In 2016 Willem Kuyken of the University of Oxford and his colleagues published a meta-analysis of published studies, including 1,258 patients who suffered from recurrent depression. Those patients who received mindfulness-based cognitive therapy had reduced risk of depressive relapse within a 60-week follow-up period compared with those receiving the usual care and other active treatments, including antidepressants.

After receiving mindfulness-based cognitive therapy, patients often report noticing that the experience of sadness fluctuates moment to moment and that negative thoughts lose their power over time. Mindfulness training in its various forms has similarly helped alleviate suffering from other psychological illnesses such as anxiety, panic disorders, PTSD, ADHD and phobias.

Mindfulness exercises can ameliorate bodily ills as well—most notably chronic pain. Because these exercises can lessen psychological stress, which can be fed by rumination about the past or worry about the future, they can reduce the emotional contribution to pain, which is often quite significant.

MINDFULNESS TRAINING CAN RELIEVE SYMPTOMS OF AILMENTS THAT STRESS CAN EXACERBATE SUCH AS PSORIASIS AND FIBROMYALGIA.

Recent data suggest that mindfulness training can also help with less severe, but still significant, psychological issues such as job-related burnout in medical professionals, first responders and teachers. Although such training is unlikely to reduce job-related demands, it may help change a person's relationship to the stressful thoughts that often accompany these demands. Indeed, there is growing evidence that mindfulness training reduces *perceived stress* and improves well-being.

Could mindfulness training protect against the harmful effects of stress on physical health? In 2016 David Creswell of Carnegie Mellon University and his colleagues examined the effects of mindfulness training on levels of a pro-inflammatory stress biomarker called interleukin 6 (IL-6). Thirty-five high-stress adults were recruited. Their stress came from the demands of seeking employment while unemployed. Participants were randomly assigned to receive mindfulness training or relaxation training

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AMISHI P. JHA and Brigadier General (now Major General) Walter Piatt review brain-wave recording procedures, along with a memory test that military service members take before and after mindfulness training.

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in the form of a three-day residential retreat. IL-6 levels were measured one month before the retreat and again four months later. Over time, IL-6 levels decreased in only the mindfulness group. To track training-related brain changes, all participants were also asked to complete a five-minute functional brain scan one month before and two weeks after the retreat. While participants were in the scanner, their only instruction was to rest. Brain scans showed that the timing of the ebb and flow of brain activity in two brain regions was more synchronized after the retreat in only the mindfulness group. The two regions were the left dorsolateral prefrontal cortex, a region known to be involved in attentional control, and the posterior cingulate cortex, a region frequently activated during episodes of mind wandering. Intriguingly, individuals in the mindfulness group who had the strongest coordination between these two regions after the retreat also had the greatest reduction in IL-6 levels over time.

How are these brain activation and biomarker levels related? Creswell and his colleagues speculated that mindfulness training strengthens attentional control to promote stress resilience, which in turn leads to reductions in stress biomarkers. Yet attention was not directly measured in their study but only inferred from brain-activation patterns.

FINDING FOCUS

AS MINDFULNESS TRAINING was gaining traction as a wellness-promotion and stress-reduction tool in the early 2000s, I began to consider, from a cognitive perspective, how it might work. As late as 2007 my field—cognitive neuroscience—had yet to weigh in on what might be changing in the brain when people engage in mindfulness training. I wondered if my own expertise on the brain bases of attention might be able to fill the gaps in our understanding. After all, there were striking parallels between current theories of distinct brain networks supporting attention and accounts from ancient texts describing practices to cultivate calm focus and open, accepting curiosity of events as they unfold.

In 2007 my research team set out to investigate. One of our first studies asked 34 medical and nursing students to perform a test of visual attention. They had to detect a target appearing at one of two locations on a computer screen. Sometimes they were told where and when the target would appear; other times they were only told when it would appear or given no warning at all. Then for eight weeks, half the subjects engaged in mindfulness exercises that required concentrated focus for 30 minutes a day. When they took the test again, these volunteers were 5 percent faster at responding during

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the trials in which they were told both where and when the target would appear, indicating that they were better at directing their attention to the cued location than the untrained participants, who showed no improvement. The results were the first hint that we were on the right track in linking mindfulness training with a person's ability to willfully direct his or her attention to specific events in the external environment.

But what about our inner landscape—the terrain of private thoughts, memories and feelings? It is well-established that consciously and willfully directing our attention to the internal milieu with a sense of curiosity or just allowing our thoughts to roam freely during an evening stroll, for example, can boost positive mood and creativity. Psychologists refer to daydreaming in this way as conscious internal reflection.

In contrast, when attention is unconsciously summoned away from the task at hand, the consequences can be grim. Mind wandering, formally defined as having off-task thoughts during an ongoing task or activity, dulls the sensory input we receive from the environment, dampens mood and makes us more error-prone. What is worse is that prolonged periods of stress can increase the frequency of mind wandering.

In 2014 research scientist Alexandra Morrison, now at California State University, Sacramento, and others in my laboratory conducted a study in undergraduate students, who are known to have degraded well-being and higher levels of perceived stress by the end of the semester. We wanted to find out if students' attention would be degraded and if their levels of mind wandering increased over the semester.

We recruited 58 university students and split them into two groups. One group received mindfulness training, and the other did not. Mindfulness expert and study co-author Scott Rogers designed a series of short, weekly mindfulness training sessions for the training group. The total training time for the program was very short: seven hours over seven weeks.

At the start of the semester and before the training began, all students were asked to complete a computerized test to index their attention and mind wandering. At predetermined intervals, the task was interrupted by a question on the screen asking if their attention was "on task" or "off task." All of the students performed at roughly the same level.

Nine weeks later, when the students were tested again, performance gaps emerged between those who received mindfulness training and those who did not. The control group performed worse than they had originally. They had more performance errors and reported greater mind wandering, whereas the students who received mindfulness training had fewer performance errors and reported less mind wandering. The mindfulness program, it seemed, not only protected them from the inevitability of getting worse as the semester went on but seemed to strengthen their attention. In line with Creswell's speculation based on his brain and biomarker data, we were finding that mindfulness training was strengthening attention and reducing

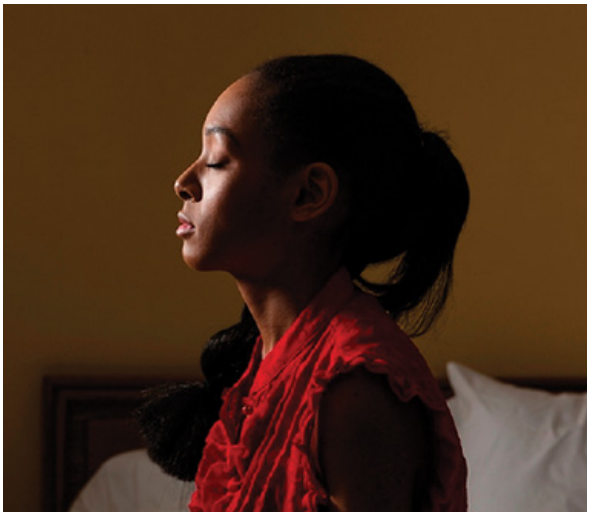
Capturing Attention

Mindfulness, a focus on the present moment without judgment, has proven benefits for health and happiness. Engaging in daily mindfulness workouts can help you assume this mental mode more often in your daily life. The following 10- to 15-minute mindfulness exercise is designed to train two types of attention: concentrative focus (a narrowing of attention and open monitoring) and a broad awareness of sensations and surroundings.

Here's what to do:

- Sit in an upright, stable position, hands resting on your thighs or cradled together.
- Lower or close your eyes, whichever is more comfortable for you.
- Attend to your breath, following its movement throughout your body.
- Notice the sensations around your belly as air flows into and out of your nose or mouth. You have been breathing all day—all of your life—and in this moment, you are simply noticing your breath.
- Select one area of your body affected by your breathing and focus your attention there. Control your focus, not the breathing itself.
- When you notice your mind wandering—and it will—bring your attention back to your breath.
- After five to 10 minutes, switch from focusing to monitoring. Think of your mind as a vast open sky and your thoughts, feelings and sensations as passing clouds.
- Feel your whole body move with your breath. Be receptive to your sensations, noticing what arises in the moment. Be attentive to the changing quality of experience—sounds, aromas, the caress of a breeze … thoughts.
- After about five more minutes, lift your gaze or open your eyes.

—Scott Rogers, director of Programs and Training, UMindfulness Research and Practice Initiative, University of Miami



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BE A BETTER YOU

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mind wandering and that it may be protective against the building stress of the semester.

We have studied many other high-stress groups from incarcerated youth, to teachers, firefighters, football players and soldiers. The results are consistent across all of these different groups. Over a high-stress interval, attentional lapses and mind wandering increase. In those receiving mindfulness training, this pattern is mitigated but only if they fully engage in daily mindfulness exercises. In other words, it is mindfulness practice that is protective, not simply sitting in a mindfulness course or listening to lectures on the merits of mindfulness training.

In some of our studies with active-duty military service members, we found that those who engaged in mindfulness exercises for 12 minutes or more every day kept their focus and mood stable over an eight-week predeployment training. The more an individual practiced, the better he or she fared, with those who practiced the most showing improvements in attention, working memory and mood by the end of the study. For a soldier, a present-focused and attentive mind may be the difference between life and death during the fog of war.

Attention may also have life-or-death consequences for our cells. In a study published in 2012 psychologist Elissa S. Epel of the University of California, San Francisco, and her colleagues found that people who self-reported a greater propensity toward mind wandering had shorter caps, called telomeres, at the ends of their chromosomes than those whose minds were more often anchored in the present. Shorter telomeres are associated with a shorter life span for an organism. As a result, the authors suggested in their paper that "a present attentional state may promote a healthy biochemical milieu and, in turn, cell longevity."

AFTER RECEIVING MINDFULNESS-BASED COGNITIVE THERAPY, PATIENTS REPORT NOTICING THAT NEGATIVE THOUGHTS LOSE THEIR POWER OVER TIME.

CULTIVATING CONSCIOUSNESS

ATTENTION IS ALMOST certainly not the only way mindfulness training works. Mindfulness techniques are most likely to alter and strengthen many other brain networks and processes. For example, studies have suggested that exercises shift the mind from a narrative mode of viewing the self, in which the central character in the story is you, to a more experiential view, in which you observe the unfolding of your thoughts, feelings and sensations over time. Whether better attention relates to this or other suggested mechanisms is not yet clear.

Whatever the mechanism, efforts to become more mindful could make a considerable dent in human suffering. Working mindfulness practices into your daily routine may bring benefits similar to those of physical exercise. Indeed, as with physical exercise, mindfulness exercises are stress-protective, and the more you do the more you benefit. As an antidote to an ambling mind, negative mood and stress, such mental workouts may have the potential to help virtually everyone live a happier, healthier and more fulfilled life. Students or athletes who want to boost their performance, for example, and parents, teachers or caregivers wishing to be more attentive to others' needs may all find mindfulness training useful. Such training may be particularly essential, however, for people such as soldiers, first responders, surgeons and air-traffic controllers whose ability to control and monitor their attention may be a matter of life or death.

With evidence of its benefits mounting come new challenges for mindfulness training. How can access be scaled-up *and* meet the needs of specific groups? Based on our past research, my colleague Scott Rogers and I created a short-form program called mindfulness-based attention training (MBAT). Once we found the core program to be effective, we developed train-the-trainer methods to address scalability challenges. MBAT's modular structure and exercises allow for flexibility so the program can be customized for a variety of groups, such as soldiers, medical students, athletes and teachers. The linchpin of the program's success is the competency of the trainers. We are finding that more so than prior expertise in mindfulness, successful trainers must be familiar with the cultural norms, sensitivities and stressors that a particular community faces. Our research is ongoing.

No matter our profession, as we learn to grab hold of our own attention, we gain control of our own happiness and health. Perhaps the time is now for us all to consider cultivating greater awareness of our moment-to-moment experiences and the contents of our consciousness. SA

Amishi P. Jha is associate professor of psychology at the University of Miami, where she serves as director of Contemplative Neuroscience for the UMindfulness Research and Practice Initiative. Her research investigates the neural bases of attention, resilience and mindfulness using brain-wave recordings and functional MRI.

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For more resources on programs and practices, see the University of Miami's UMindfulness Initiative Web site: **mindfulness.miami.edu/umindfulness/resources**

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THE HAPPY COUPLE

The key to keeping the magic alive in a marriage, experts say, is finding ways to promote the positive

By Suzann Pileggi Pawelski

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LISA, AN ELEMENTARY SCHOOL TEACHER FROM AMBLER, PA., CAME HOME FROM work one day and said to her husband, "Honey, guess what? I landed that summer teaching position I wanted!" "Wow, congratulations!" he replied. "I know how hard you worked to get that job. I am so happy for you! You must be really excited." The way Lisa's husband reacted to her good news was also good news for their marriage, which, more than 20 years later, is still going strong; such positive responses turn out to be vital to the longevity of a relationship. Numerous studies show that intimate relationships, such as marriages, are the single most important source of life satisfaction. Although most couples enter these relationships with the best of intentions, many break up or stay together but languish. Yet some do stay happily married and thrive. What is their secret?

A few clues emerge from the latest research in the nascent field of positive psychology. Founded in 1998 by psychologist Martin E. P. Seligman of the University of Pennsylvania, this discipline includes research into positive emotions, human strengths and what is meaningful in life. Positive psychology researchers have discovered that thriving couples accentuate the positive in life more than do those who stay together unhappily or split. They not only cope well during hardship but also celebrate the happy moments and work to build more bright points into their lives.

It turns out that how couples handle good news may matter even more to their relationship than their ability to support each other under difficult circumstances. Happy pairs also individually experience a higher ratio of upbeat emotions to negative ones than people in unsuccessful liaisons do. Certain tactics can boost this ratio and thus help to strengthen connections with others. [*To measure your positivity ratio, see box on page 66.*] Another ingredient for relationship success: cultivating passion. Learning to become devoted to your significant other in a healthy way can lead to a more satisfying union.

LET THE GOOD TIMES ROLL

UNTIL RECENTLY, studies largely centered on how romantic partners respond to each other's misfortunes and on how couples manage negative emotions such as jealousy and anger—an approach in line with psychology's traditional focus on alleviating deficits. One key to successful bonds, the studies indicated, is believing that your partner will be there for you when things go wrong. Then, in 2004, psychologist Shelly L. Gable, currently at the University of California, Santa Barbara, and her colleagues found that romantic couples share positive events with each other surprisingly often, leading the scientists to surmise that a partner's behavior also matters when things are going well.

In a study published in 2006 Gable and her co-workers videotaped dating men and women in the laboratory while the subjects took turns discussing a positive and negative event. After each conversation, members of each pair rated how "responded to"—how understood, validated and cared for—they felt by their partner. Meanwhile observers rated the responses on how active-constructive (engaged and supportive) they were—as indicated by intense listening, positive comments and questions, and the like. Low ratings reflected a more passive, generic response such as "That's nice, honey." Separately, the couples evaluated their commitment to and satisfaction with the relationship.

The researchers found that when a partner proffered a supportive response to cheerful statements, the "responded to" ratings were higher than they were after a sympathetic response to negative news, suggesting that how partners reply to good news may be a stronger determinant of relationship health than their reaction to unfortunate incidents. The reason for this finding, Gable surmises, may be that fixing a problem or dealing with a disappointment—though important for a relationship—may not make a couple feel joy, the currency of a happy pairing.

In addition, couples who answered good news in an active-constructive way scored higher on almost every type of measure of

IN BRIEF

In the past few years psychologists have discovered that thriving couples accentuate the positive in life more than do those who languish or split. They not only cope well during hardship but also celebrate the happy moments and work to build more of these into their lives.

How couples handle good news may matter even more to their relationship than does their ability to support each other under difficult circumstances.

Members of happy couples also individually experience a higher ratio of upbeat emotions to negative ones than do people in unsuccessful pairings. Certain tactics can boost this ratio and thus help to strengthen bonds with others.

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1

MUTUAL SUPPORT and enthusiasm in *good* times are essential to a successful relationship, according to the latest research in positive psychology.

2

PASSIVE RESPONSES to exuberant announcements indicate a lack of interest—and are almost as damaging to a relationship as directly disparaging a partner's good news.

relationship satisfaction than those who responded in a passive or destructive way. (Passive replies indicate a lack of interest, as in changing the subject, and destructive responses include negative statements such as "That sounds like tons of work!") Surprisingly, a passive-constructive response ("That's nice, honey") was almost as damaging as directly disparaging a partner's good news. These data are consistent with an earlier study showing that active-constructive responders experience fewer conflicts and engage in more fun activities together. These individuals also are more likely to remain together. Active-constructive responding shows that a person cares about why the good news is important, Gable says, conveying that you "get" your partner. Conversely, negative or passive reactions signify that the responder is not terribly interested—in either the news or the person disclosing it.

LIFE AFFORDS MANY OPPORTUNITIES TO RESPOND SUPPORTIVELY TO OPTIMISTIC ANNOUNCEMENTS: POSITIVE EVENTS HAPPEN AT LEAST THREE TIMES AS OFTEN AS NEGATIVE ONES, ONE STUDY SUGGESTS.

Thankfully, life affords many opportunities to respond supportively to optimistic announcements: Gable, along with social psychologist Jonathan Haidt, now at New York University Stern School of Business, reported in 2005 that, for most individuals, positive events happen at least three times as often as negative ones. And just as responding enthusiastically to your partner's good news increases relationship satisfaction so does sharing your own positive experiences. In a daily diary study of 67 cohabiting couples published in 2010 in *Advances in Experimental Social Psychology,* Gable found that on days when couples reported telling their partner about a happy event they also reported feeling a stronger tie to their partner and greater security in their match.

POWER OF POSITIVE EMOTIONS

REVELING IN THE GOOD TIMES boosts the positive emotions of both members of a couple. Three decades ago positive psychology pioneer Barbara L. Fredrickson of the University of North Carolina at Chapel Hill showed that positive emotions, even fleeting ones, can broaden our thinking and enable us to connect more closely with others. Having an upbeat outlook, she argues, enables people to see the big picture and avoid getting hung up on small annoyances. This wide-angle view often brings to light new possibilities and offers solutions to difficult problems, making individuals better at handling adversity in relationships and other parts of life. It also tends to dismantle boundaries between "me" and "you," creating stronger emotional attachments. "As positivity broadens your mind, it shifts your core view of people and relationships, bringing them closer to your center, to your heart," Fredrickson says.

When a person's positive sentiments outnumber negative feelings by three to one, that individual tends to become more resilient in life and love, Fredrickson found. Among individuals in enduring and mutually satisfying marriages, ratios tend to be even higher, hovering around five to one, according to research by world-renowned marriage expert John Gottman, emeritus professor of psychology at the University of Washington.

In her book *Positivity* (Crown, 2009), Fredrickson lists the 10 most frequent positive emotions: joy, gratitude, serenity,

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How *Positive* Are You?

Although all healthy relationships involve some negative feelings, positive emotions form the foundation of any strong pairing. Psychologist Barbara L. Fredrickson of the University of North Carolina at Chapel Hill found that individuals who thrive in and outside relationships tend to experience a ratio of three or more positive emotions for every negative one in their daily lives. To find out how you compare, take the following quiz, called the Positivity Self Test, developed by Fredrickson in 2009.

1. What is the most amused, fun-loving or silly you felt?
2. What is the most angry, irritated or annoyed you felt?
3. What is the most ashamed, humiliated or disgraced you felt?
4. What is the most awe, wonder or amazement you felt?
5. What is the most contemptuous, scornful or disdainful you felt?
6. What is the most disgust, distaste or revulsion you felt?
7. What is the most embarrassed, self-conscious or blushing you felt?
8. What is the most grateful, appreciative or thankful you felt?
9. What is the most guilty, repentant or blameworthy you felt?
10. What is the most hate, distrust or suspicion you felt?
11. What is the most hopeful, optimistic or encouraged you felt?
12. What is the most inspired, uplifted or elevated you felt?
13. What is the most interested, alert or curious you felt?
14. What is the most joyful, glad or happy you felt?
15. What is the most love, closeness or trust you felt?
16. What is the most proud, confident or self-assured you felt?
17. What is the most sad, downhearted or unhappy you felt?
18. What is the most scared, fearful or afraid you felt?
19. What is the most serene, content or peaceful you felt?
20. What is the most stressed, nervous or overwhelmed you felt?

Instructions

Using the scale below, indicate the greatest degree to which you have experienced each of the following emotions during the previous 24 hours.

0 = Not at all
1 = A little bit
2 = Moderately
3 = Quite a bit
4 = Extremely

Scoring

Circle questions 1, 4, 8, 11, 12, 13, 14, 15, 16 and 19 and then underline questions 2, 3, 5, 6, 7, 9, 10, 17, 18 and 20.

Count the number of circled (positivity) questions you rated 2 or higher and the number of underlined (negativity) questions you scored 1 or higher.

Divide your positivity tally by your negativity tally. (If your negativity tally is zero, replace it with a 1.) The result represents your positivity ratio for today.

If you scored below 3:1, as most Americans do, you may be able to raise that ratio with exercises recommended in this article and in Fredrickson's book, *Positivity* (Crown, 2009). Because this test provides a mere snapshot of your feelings during the previous 24 hours, you may also want to repeat it nightly for two weeks to gain a more reliable assessment of your positivity ratio.

For more details as well as for a convenient way to test yourself, visit www.positivityratio.com.

interest, hope, pride, amusement, inspiration, awe and love. Although all these emotions matter, gratitude may be one of the most important for relationships, she says. Expressing gratitude on a regular basis can help you appreciate your partner rather than taking his or her small favors or kind acts for granted, and that boost in appreciation strengthens your relationship over time.

In a study published in 2010 in *Personal Relationships,* social psychology researcher Sara B. Algoe, also at U.N.C. Chapel Hill, and her colleagues asked cohabiting couples, 36 percent of whom were married or engaged, to report nightly for two weeks how grateful they felt toward their partners from their interactions that day. In addition to gratitude, they numerically rated their relationship satisfaction and their feelings of connection with their partner. On days that people felt more gratitude toward their partner, they felt better about their relationship and more connected to him or her; they also experienced greater relationship satisfaction the *following* day. Additionally, their partners (the recipients of the gratitude) were more satisfied with the relationship and more connected to them on that same day. Thus, moments of gratitude may act as a booster shot for romantic relationships.

The fact that gratitude affected both partners also hints that *expressing* your gratitude is important for relationship satisfaction. To test this idea directly, Algoe, Fredrickson and their colleagues asked people in romantic relationships to list nice things their partners had done for them lately and to rate on a scale from 1 (not at all) to 7 (very much) how well they thought they had expressed appreciation to their partner for having done those favors. The researchers found that each unit improvement in expressed appreciation decreased by half the odds of the couple breaking up in six months.

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PROMOTING PASSION

LIKE GRATITUDE, feelings of passion can strengthen our bonds with others. Many people equate passion with a desperate longing, suggested by song lyrics such as "I can't live without you" and "You're my everything." But such unbridled or obsessive passion is not conducive to a healthy relationship, according to work by social psychologist Robert J. Vallerand of the University of Quebec at Montreal. On the contrary, obsessive passion—a type that seems to control you—is as detrimental to the relationship, making it less satisfying sexually and otherwise, as having no passion.

A healthy passion—a voluntary inclination toward an activity or person whom we love and value—does provide benefits, however. It is associated with relationship satisfaction and constructive behavior during tough times, whereas obsessive passion predicts destructive behavior during conflicts and breakups over time. Using the Romantic Passion Scale, a questionnaire that measures harmonious and obsessive passion, Vallerand found that harmonious passion helps couples relate better, in part by enabling them to become intimate with their partner while maintaining their own identity, which helps to foster a more mature partnership. Their intimacy enables them to continue to pursue their own hobbies and interests rather than subjugating their own sense of self to an excessive attachment to the other person. (Previous research by Vallerand and his colleagues revealed that harmonious passion for activities leads to cognitive and emotional advantages, such as better concentration, a more positive outlook and better mental health. No one has yet studied whether these benefits spill over to our romantic relationships, however.)

MANY PEOPLE EQUATE PASSION WITH A DESPERATE LONGING, BUT SUCH UNBRIDLED OR OBSESSIVE PASSION IS NOT CONDUCIVE TO A HEALTHY RELATIONSHIP, RECENT RESEARCH INDICATES.

You can cultivate healthy passion by joining your partner in a pursuit that both of you enjoy, Vallerand suggests. Engaging in exhilarating activities with another person has been shown to boost mutual attraction. Avoid serious competition because the point of the outing should not be winning but enjoying time together. Another tip: write down and share with your partner some of the reasons why you love him or her and why your relationship is important.

POSITIVE STEPS

EXPERTS ALSO HAVE TIPS for injecting positive emotions into your life. First, learn to respond constructively to your partner's positive declarations. Look for opportunities to express your interest, support and enthusiasm. Acknowledge a terrific presentation at work, say, or faster time in a road race. Ask yourself regularly: "What good news has my partner told me today? How can we celebrate it?" Affirm your partner's joy first. Discuss your concerns, such as the practical downsides of a promotion, at a later time. In addition, be attentive and actively participate in the conversation. Ask questions and indicate interest nonverbally: maintain eye contact, lean forward and nod. To show you heard, rephrase a part of what he or she said, for instance: "You seem really excited about this new job."

Simply willing ourselves to feel positive emotions is not effective. In fact, valuing happiness too much may even backfire. Instead Fredrickson emphasizes the importance of taking action to "prioritize positivity." In other words, making choices and organizing our lives in ways that we are more likely to experience positive emotions. People who prioritize positivity have greater psychological resources such as resilience and self-compassion. Schedule exuberant feelings into your day by, say, making time for activities that evoke such emotions. Locate places you can walk to quickly to connect with nature or other beautiful scenery. Make these places regular destinations for exercising, reflecting or hanging out with friends. In addition, practice savoring a genuine source of positive emotion that is currently, has been or will be a part of your life.

Another idea for raising your personal positivity score: create a "positivity portfolio," a collection of meaningful mementos signifying a positive emotion. For example, you might encapsulate joy by creating a collage of uplifting song lyrics and pictures that make you smile. Looking at your creation every day for 20 minutes can improve your positivity score. Try infusing fun or pleasure into mundane tasks. For instance, transform dinner preparation into a family activity in which the kids help by measuring ingredients and slicing vegetables, Fredrickson says. Turn daily challenges or snafus, like your child's misplaced shoes, into a game to see who can find them first.

Look for opportunities to thank your partner. "Try highlighting those small moments in which your partner has been thoughtful and expressing it to him or her," Fredrickson suggests. And find time each day to share something positive that has happened to you. SA

Suzann Pileggi Pawelski holds a master of applied positive psychology (MAPP) from the University of Pennsylvania. She blogs for *Psychology Today* and is co-author, along with her husband, James O. Pawelski, of *Happy Together: Using the Science of Positive Psychology to Build Love That Lasts* (TarcherPerigee, 2018).

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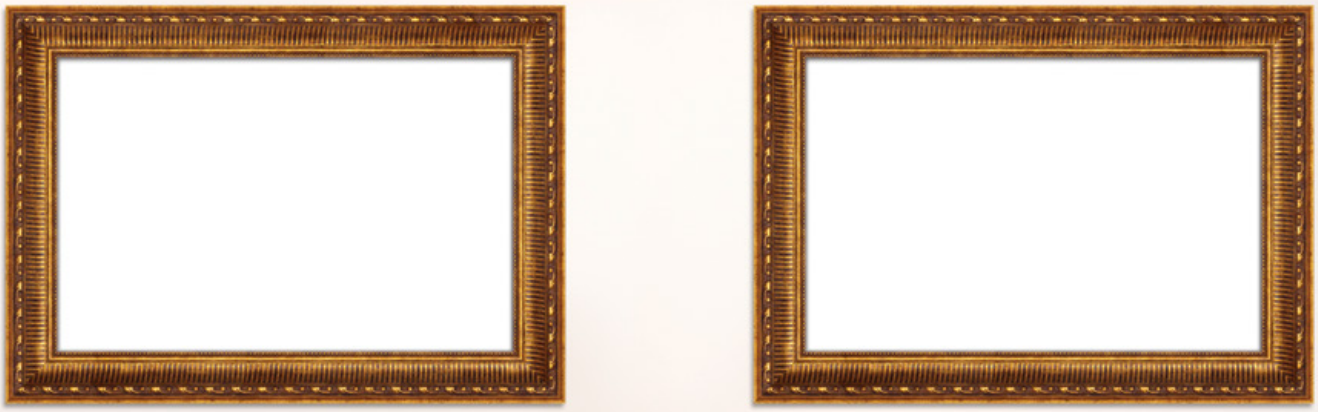

THE PURSUIT OF HAPPINESS

OPENNESS TO EXPERIENCE: THE GATES OF THE MIND

People who are "open to experience" literally see the world differently

By Luke D. Smillie

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WHAT DOES IT MEAN TO BE "OPEN-MINDED?" ARE SOME PEOPLE genuinely more inclusive in their thinking, more expansive in how they process information? Experiments in personality psychology show that open-minded people do indeed process information in different ways and may literally *see the world differently* from the average person. The personality trait that best reflects the lay concept of open-mindedness is called "openness to experience," or simply "openness." Open people tend to be intellectually curious, creative and imaginative. They are interested in art and are voracious consumers of music, books and other fruits of culture. They also tend to be politically liberal. According to personality theorists, openness reflects a greater "breadth, depth, and permeability of consciousness" and propensity to "cognitively explore" both abstract information (ideas and arguments) and sensory information (sights and sounds). In other words, open people engage with the various percepts, patterns and perspectives that clamor for space in our mind—information is like catnip for their brain.

These abstract notions may well seem like academic hand waving, but they are anchored in concrete data from many research studies. For example, consider the superior performance by open people on tests of creativity called divergent thinking tasks. These require individuals to generate multiple, diverse solutions to a simple problem, such as: "How many uses can you think of for a brick?" Less open people typically generate fewer and more obvious answers to this question—building walls, building houses, building other stuff. But for highly open people, the possibilities flood in. A brick can be used as a weapon, a paperweight, a replacement leg for a broken sofa. Or it can be smashed up and mixed with water to

IN BRIEF

People who are "open to experience" tend to be intellectually curious, creative and imaginative. Personality researchers have shown that such people literally see the world differently.

Less open people experience latent inhibition, a brain function that filters out extraneous visual and cognitive input. But highly open people are less subject to such cognitive inhibition.

Because their perception allows more information to flow into their visual system, more open people tend to see things that others block out. Researchers also found that open people can feel very complex emotional states because seemingly incompatible feelings break through into their consciousness simultaneously.

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make paint. Open people see more possibilities in even the most mundane of objects.

We see something similar in studies of latent inhibition, a process also known as learned irrelevance. Learning what to ignore is critical for effective psychological functioning—it would be simply overwhelming to process the full stream of information available to our senses as we make our way through the world. So we cull through this information for relevant details, screening out everything else. The problem is, the screened-out information might be useful later, but by then we are slow to realize its significance, to *unlearn* its irrelevance. This process can be modeled in the laboratory by preexposing participants to seemingly unimportant stimuli that later form the basis of a learning task. For the average person, this preexposure stifles subsequent learning—the critical stimulus has been rendered "irrelevant" and fails to penetrate awareness. Not so, however, for those high in openness, who are less susceptible to latent inhibition. This again demonstrates a more inclusive mode of thinking—a "leaky" cognitive system, if you will—that lets in information that others filter out.

These studies show that open people are less susceptible to the psychological "blind spots" that help us pare back the complexity of the world. And research shows that this characterization is more than a metaphor: open people literally see things differently in terms of basic visual perception.

HIGHLY OPEN PEOPLE ARE LESS SUSCEPTIBLE TO INATTENTIONAL BLINDNESS: THEY TEND TO SEE THE THINGS THAT OTHERS BLOCK OUT.

Consider inattentional blindness—the screening out of visual information beyond our attentional focus. You have experienced this if you have ever been so preoccupied with one thing that you failed to see something else right in front of your eyes. (Smartphone-jabbing pedestrians dawdling along the bike path, this means you.) In a classic study often dubbed the "Invisible Gorilla" test, researchers showed participants a film clip of several people passing a basketball back and forth and asked them to count the number of passes between players in white and to ignore the players in black. During the film, someone in a gorilla costume wanders in among the players. In full view, this hairy interloper looks into the camera, beats its chest and drifts off again. Amazingly, most participants in this study reported that they did not see anything unusual or surprising during the clip. Highly open people, on the other hand, are less susceptible to inattentional blindness: they tend to see the things that others block out.

My colleagues and I at the University of Melbourne in Australia have explored these ideas further. In one recent study, we examined links between openness and a perpetual phenomenon called binocular rivalry. This occurs when one image is presented to our left eye while a different image is presented to the right eye. Because the brain cannot extract a coherent picture from these incompatible percepts, the two images seem to flip back and forth in our mind's eye, each image rivaling the other for dominance. But sometimes both images do break through into conscious perception as a scrambled mash-up. In our study, we found that open people perceived this "mixed percept" for longer periods. It is as though the gates of perception are agape, allowing more visual information to flow into consciousness for open people.

We have also examined how these findings extend to a very different kind of experience called mixed emotions—the simultaneous experience of contrasting feeling states (bittersweetness, nervous excitement, and so on). Might open people also be susceptible to such experiences, to have seemingly incompatible *feelings* break through into conscious experience, analogous to the two percepts in binocular rivalry? Indeed, we found that such individuals do report experiencing mixed emotions more frequently in their lives. This may be another example of the "permeability of consciousness," in this case giving rise to complex emotional experiences.

What is happening in the brains of open people to produce these distinctive experiences? Here our knowledge is far murkier and less certain, the neuroscience of personality being a fraught and fledgling field. Some evidence implicates dopamine, a neurochemical that—among many other functions—signals the incentive value of information. This process might explain why open people seem to have more sensitive radars for detecting and processing all kinds of concepts, percepts and qualia. Another clue is an association between openness and activity in the "default network," a neural system that simulates various experiences such as mind wandering, mental time travel and imagining others' point of view. More research is needed to determine whether these neural processes underpin the flexible and inclusive cognition that characterizes open people.

As personality psychologists delve deeper into openness to experience, we push back the boundaries of knowledge of this fascinating trait. Is it an advantage to be higher on openness, or are there downsides? Can we change our level of openness and, if so, how? Is openness a uniquely human trait? How did it evolve? As the answers to these questions unfold, we better understand what it means to be open-minded and how it shapes our experience of the world. SA

Luke D. Smillie is a senior lecturer in psychology at the University of Melbourne in Australia and has published numerous research papers on personality and individual differences. He was awarded his Ph.D. from the University of Queensland in Australia, has held positions at the University of London and is now director of the Personality Processes Lab at Melbourne.

MORE TO EXPLORE

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THE PURSUIT OF HAPPINESS

THE JOYFUL MIND

BE A BETTER YOU

A new understanding of how the brain generates pleasure could lead to better treatment of addiction and depression—and even to a new science of happiness

By Morten L. Kringelbach and Kent C. Berridge

IN BRIEF

New research has uncovered hotspots in the brain that, when stimulated, enhance sensations of pleasure.

These hedonic hotspots differ from the "reward circuit" previously thought to be the basis of good feelings—a pathway now believed to mediate desire more than enjoyment.

Higher brain regions receive information from these pleasure and reward circuits to consciously represent the warm glow we associate with joy.

A decoupling of the brain systems that generate "wanting" and "liking" may underlie addictive behavior—a clue that may lead to new treatments.

SCIENTIFIC AMERICAN (*photo illustration*); GETTY IMAGES (*head outline*); THINKSTOCK (*images inside head*); NASA (*moon*)

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IN THE 1950S PSYCHIATRIST ROBERT HEATH OF TULANE UNIVERSITY LAUNCHED a controversial program to surgically implant electrodes into the brains of patients institutionalized with epilepsy, schizophrenia, depression and other severe neurological conditions. His initial objective: to locate the biological seat of these disorders and, by artificially stimulating those regions, perhaps cure individuals of their disease. According to Heath, the results were dramatic. Patients who were nearly catatonic with despair could be made to smile, converse, even giggle. But the relief was short-lived. When the stimulation ceased, the symptoms returned.

To extend the potential therapeutic benefit, Heath fitted a handful of patients with buttons they could press themselves whenever they felt the urge. Some felt the urge quite frequently. One patient—a 24-year-old gay man whom Heath was attempting to cure of depression (and of his desire for other men)—was compelled to stimulate his electrodes some 1,500 times over the course of a single, three-hour session. According to Heath, this obsessive self-stimulation gave the subject, patient B-19, "feelings of pleasure, alertness, and warmth (goodwill)." The end of his session was met with vigorous protest.

The experiments helped to define a set of structures that would come to be known as the pleasure center of the brain. They also spawned a movement—both in science and in popular culture—to better understand the biological basis of pleasure. Over the next 30 years neurobiologists identified the chemicals that the brain regions delineated by Heath and others send and receive to spread their tidings of joy. And people began to imagine brave new worlds in which activation of these centers could produce instant bliss.

Yet the discovery of the brain's alleged pleasure center has not led to any breakthroughs in the treatment of mental illness. It may have even misled scientists into thinking they understood how pleasure is encoded and generated within the brain. Studies in rodents and humans now suggest that activating these structures with electrodes or chemicals does not actually produce pleasure at all. It may merely precipitate craving and hence the manic drive to self-stimulate.

With the help of modern molecular biological techniques, combined with improved methods for deep-brain stimulation, our laboratories and others are redefining the brain's pleasure circuitry. We are finding that the pleasure-generating systems in the brain are much more restricted—and much more complex—than previously thought. By pinpointing the true neurological underpinnings of pleasure, we hope to pave the way to more targeted and effective treatments for depression, addiction and other disorders—and perhaps to offer new insights into the roots of human happiness.

MISLEADING ELECTRODES

WHETHER EXPERIENCED as shivers of delight or the warm thrum of contentment, pleasure is more than an ephemeral extra—that is, something to be sought only after one's more basic needs have been met. The sensation is actually central to life. Pleasure nourishes and sustains animals' interest in the things they need to survive. Food, sex and, in some cases, social communion generate positive feelings and serve as natural rewards for all animals, including ourselves.

The first apparent insights into the biological basis of these feelings came nearly 60 years ago from the original discoverers of the so-called pleasure electrodes. James Olds and Peter Milner of McGill University were searching for brain regions that could influence animal behavior. Earlier studies from Yale University—in which electrodes had been inserted into rats' brains—had identified an area that, when stimulated, would cause an animal to avoid whatever action had coincided with the stimulation. While trying to replicate these findings, Olds and Milner came across a brain region that the rodents would take active steps to stimulate—in the same way that animals will repeat any task or behavior that yields a suitable reward.

Placing the electrodes in different regions—and sometimes not where they intended—the pair were surprised to find a part of the brain that animals seemed to enjoy having zapped with a mild electric current. Rats placed in a large box returned repeatedly to the corner in which the researchers would give them a small electric jolt. Using this approach, Olds and Milner found they could steer the rodents to almost any location. In some instances, the animals even chose stimulation over food.

Even more surprising, when the electrodes were wired so that the rats could stimulate their own brain by pressing a lever, Olds and Milner discovered that they did so almost obsessively—some more than 1,000 times an hour [see "Pleasure Centers in the Brain," by James Olds; SCIENTIFIC AMERICAN, October 1956]. When the current was turned off, the animals would press the bar a few more times—and then go to sleep.

The results prompted Olds and Milner to declare, "We have perhaps located a system within the brain whose peculiar function is to produce a rewarding effect on behavior." The regions the researchers identified—including the nucleus accumbens, which reclines at the base of the forebrain, and the cingulate cortex, which forms a collar around the fibrous bundle that bridges the brain's left and right halves—thus became enshrined as the operational base of the brain's reward circuit.

Almost immediately other scientists reproduced these effects, making similar findings in higher primates and humans.

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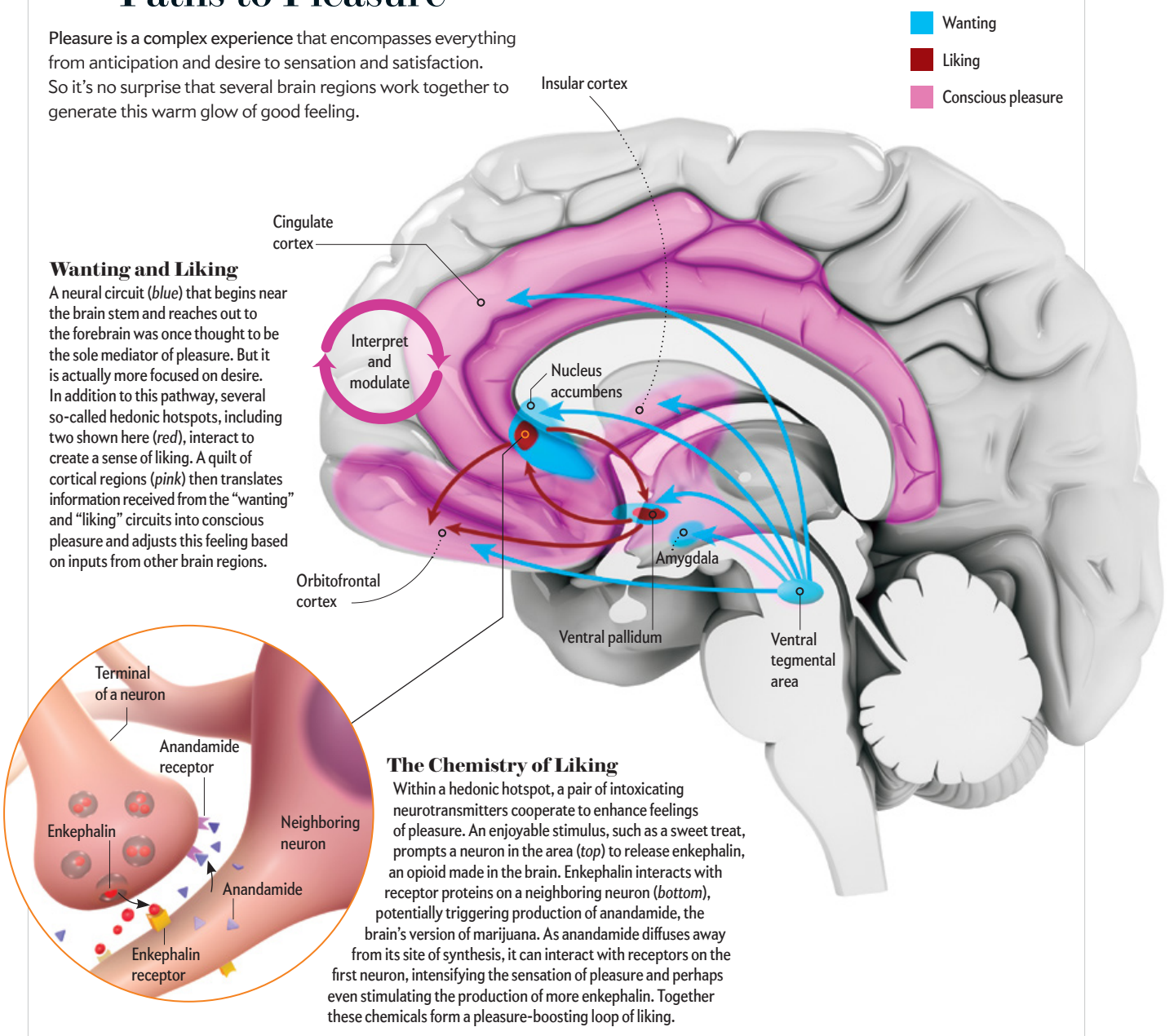
Paths to Pleasure

Pleasure is a complex experience that encompasses everything from anticipation and desire to sensation and satisfaction. So it's no surprise that several brain regions work together to generate this warm glow of good feeling.



Wanting and Liking

A neural circuit (*blue*) that begins near the brain stem and reaches out to the forebrain was once thought to be the sole mediator of pleasure. But it is actually more focused on desire. In addition to this pathway, several so-called hedonic hotspots, including two shown here (*red*), interact to create a sense of liking. A quilt of cortical regions (*pink*) then translates information received from the "wanting" and "liking" circuits into conscious pleasure and adjusts this feeling based on inputs from other brain regions.

The Chemistry of Liking

Within a hedonic hotspot, a pair of intoxicating neurotransmitters cooperate to enhance feelings of pleasure. An enjoyable stimulus, such as a sweet treat, prompts a neuron in the area (*top*) to release enkephalin, an opioid made in the brain. Enkephalin interacts with receptor proteins on a neighboring neuron (*bottom*), potentially triggering production of anandamide, the brain's version of marijuana. As anandamide diffuses away from its site of synthesis, it can interact with receptors on the first neuron, intensifying the sensation of pleasure and perhaps even stimulating the production of more enkephalin. Together these chemicals form a pleasure-boosting loop of liking.

Heath, in particular, pushed the interpretation of his results to the limit, insisting that stimulating these regions not only reinforces a behavior but produces sensations of intense pleasure. In the minds of many scientists and the general public, these structures became known as the brain's chief pleasure center.

About 15 years ago, though, the two of us began wondering whether the act of electrical self-stimulation was really the best measure of pleasure. How do we know that subjects stimulate those regions because they like the way it feels and not for some other reason? To probe the pleasure circuitry more precisely, we felt we needed to devise a different way of assessing what subjects—including animals—actually enjoy.

A MEASURE OF PLEASURE

FOR EXPERIMENTS IN PEOPLE, assessing pleasure is fairly straightforward: just ask. Of course, the resulting ratings might not fully capture or accurately reflect the underlying sensations. Further, such inquisition is not possible in lab animals—the subjects in which biology is most easily explored.

An alternative approach takes its lead from Charles Darwin. In his 1872 book *The Expression of the Emotions in Man and Animals,* Darwin noted that animals change their affect in response to environmental situations—in other words, they make faces. We now know that the neural mechanisms underlying such expressions work similarly in most mammalian brains.

Illustration by AXS Biomedical Animation Studio

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Hence, certain facial gestures have been conserved in animals as distantly related as rodents and humans—including the "yummy faces" we make in response to tasty food.

Food is one of the most universal routes to pleasure—as well as an essential requirement for survival. It is also one of the most accessible experimental tools used by psychologists and neuroscientists studying animal behavior. In our studies, we have found that the response to food provides a window through which we can observe unspoken pleasures.

Anyone who has spent time around babies knows that even the youngest humans have ways of advising their caregivers about the palatability of a meal. Sweet tastes elicit a contented licking of the lips, whereas bitter tastes tend to be met with gaping mouths, shaking heads and a vigorous wiping of the mouth. The same responses seen in human infants also occur in rats, mice and nonhuman primates. The more subjects like the taste, the more often they will lick their lips. By making video recordings of subjects' responses to food and then counting the number of times their tongues dart out—as if to capture every last molecule of flavor—we can measure how much a given gustatory stimulus is liked. And we have used that information to assess where pleasure really resides in the brain.

PLEASURE DOES NOT ARISE IN THE BRAIN QUITE WHERE—OR HOW—PAST THINKING SAID IT SHOULD.

WANTING IS NOT LIKING

ONE OF THE FIRST THINGS we discovered is that pleasure does not arise in the brain quite where—or how—past thinking said it should. The regions first identified by Olds and Milner and others, positioned at the front of the brain, are activated by the neurotransmitter dopamine, released by neurons that originate near the brain stem. If these frontal areas truly regulate pleasure, we reasoned, flooding them with dopamine—or removing dopamine entirely—should alter how an animal responds to an enjoyable stimulus. That is not what we found.

For these experiments, our colleague Xiaoxi Zhuang of the University of Chicago engineered mice lacking a protein that retrieves dopamine once it has been released by an excited neuron, returning the neurotransmitter to the cell's interior. Animals with such a knockout mutation maintain unusually high concentrations of dopamine throughout their brain. Yet we found that the mice do not appear to derive more pleasure from sweets than their unaltered cage mates do. Relative to normal rodents, the dopamine-doped mice do speed more quickly toward sweet rewards; however, they do not lick their lips any more often. On the contrary, they do so even less than mice with average amounts of dopamine.

We see the same thing in rats that have dopamine elevated by other means. For example, injecting amphetamine into the nucleus accumbens causes dopamine in that area to rise. Again, however, sugary treats seem no more pleasant to these rats after their chemically assisted dopamine boost—although the animals are more motivated to obtain them.

Conversely, rats that have been depleted of their dopamine show no desire for sugary treats at all. These animals will actually starve to death unless they are actively nursed. Yet dopamine-free rats that have no interest in food nonetheless find whatever sweets might be placed into their mouth whisker-licking good.

So it seems that dopamine's effects may be subtler than previously understood. The chemical appears to contribute more to motivation than to the actual sensation of pleasure itself. In humans, too, dopamine levels appear to track more closely with how much individuals claim to "want" a delicious tidbit than with how much they say they "like" it.

The same may be true in addiction. Drugs of abuse flood the brain with dopamine—particularly those regions associated with "wanting." This dopamine barrage not only triggers intense craving, it renders cells in these regions more sensitive to future drug exposure. Moreover, work from our colleague Terry Robinson of the University of Michigan suggests that this sensitization can persist for months or years. Thus, even after the drug no longer brings pleasure, Robinson reasons, an addict can still feel a strong urge to use—an unfortunate consequence of dopamine's actions.

Given this new understanding, we believe that the "pleasure" electrodes that stimulate accumulation of this chemical in the brains of rats—and humans—might not have been as enjoyable as was originally assumed. In support of this view, we find that activation of electrodes that elevate dopamine in the nucleus accumbens will motivate a rat to eat and drink, yet the same stimulation does not make that food more pleasing—just the opposite. Rats that are moved to eat sweets by electrical stimulation wipe their mouth and shake their head—signs of active dislike, as if the current had rendered the sweetness bitter or disgusting to them. The fact that the electrodes compel rats to consume large quantities of a food that is not bringing them pleasure is evidence that wanting and liking are controlled by different mechanisms in the brain.

We think the differential control also occurs in humans. The application of current through the classic pleasure electrodes led at least one patient to a strong desire to drink. In others, including B-19, electrical stimulation triggered an urge for sex. At the time, such sexual cravings were considered evidence of pleasure. Yet in our extensive reviews of the literature, we have never come across evidence that a patient implanted with these electrodes found them expressly pleasurable. B-19 never once exclaimed, "Oh, that feels nice!" Instead stimulation of the pleasure electrodes simply made him and the others want more stimulation—probably not because they liked it but because they were made to desire it.

HEDONIC HOTSPOTS

WANTING AND LIKING are both involved in making an experience feel rewarding. So it makes sense that the real pleasure centers in the brain—those directly responsible for generating pleasurable sensations—turn out to lie within some of the structures previously identified as part of the reward circuit. One of these so-called hedonic hotspots lies in a subregion of the nucleus accumbens called the medial shell. A second is found within the ventral pallidum, a deep-seated structure near the base of the forebrain that receives most of its signals from the nucleus accumbens.

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To locate these hotspots, we searched for brain regions that, when stimulated, amplify the sensation of pleasure—for example, making sweet things even more enjoyable. Chemically stimulating these hotspots with enkephalin—a morphinelike substance made in the brain—enhances a rat's liking of sweets. Anandamide, the brain's version of the active ingredient in marijuana, does the same. Another hormone called orexin, which is released by the brain during hunger, may also stimulate hedonic hotspots, helping to enhance the flavor of food.

Each of these spots is just a fraction of the size of the larger structure in which it lies—only about one cubic millimeter in a rat brain and probably no more than a cubic centimeter in a human. Yet like the islands of an archipelago, they link to one another—and to other brain regions that process pleasure signals—to form a powerful, integrated pleasure circuit.

That circuit is fairly resilient. In our experience, disabling individual components within the pleasure circuit does not diminish the typical response to a standard sweet—with one exception. Damaging the ventral pallidum appears to eliminate an animal's ability to enjoy food, turning a nice taste nasty.

On the other hand, intense euphoria is harder to come by than everyday pleasures. The reason may be that strong enhancement of pleasure—like the chemically induced pleasure bump we produced in lab animals—seems to require activation of the entire network at once. Defection of any single component dampens the high.

Whether the pleasure circuit—and in particular, the ventral pallidum—works the same way in humans is unclear. Not many people come to the clinic with discrete damage to these structures without injuries in surrounding areas. Thus, it is difficult to assess whether the ventral pallidum and other components in the circuit are essential to the sensation of pleasure in humans. We know of one patient whose ventral pallidum became damaged during a massive drug overdose. Afterward, he reported that his feelings were dominated by depression, hopelessness, guilt and an inability to feel pleasure—potentially supporting a central role for this heretofore underappreciated structure.

ENOUGH IS ENOUGH

THE CIRCUIT does not act alone in regulating feelings of joy. To add that warm gloss of pleasure to a sensation or experience, additional brain regions come into play. These higher structures help to determine how delightful an experience is, based on current conditions, such as whether one is hungry or full or has simply had enough of one particular pleasure. After eating an entire pan of brownies, for example, even an admitted chocoholic tends to find a candy bar much less appealing.

In the case of food, such selective satiety may have evolved in part because it encourages animals to obtain a wide variety of nutrients rather than fixating on one favorite meal. It seems to be encoded in a part of the brain called the orbitofrontal cortex. This area, located in the underbelly of the prefrontal cortex, which in humans hangs just above the eyes, receives information from the nucleus accumbens and ventral pallidum. It seems to modulate how pleasure is consciously represented—suffusing a sensation with that delicious glow we associate with gratification and toning down the feelings when enough is enough.

With the help of powerful neuroimaging techniques, we have found that the activity of a small region within the orbitofrontal cortex, called the midanterior site, correlates tightly with the subjective pleasantness of a nice sensation, such as the taste of chocolate milk. At the first sip, for example, the site is alight with activity. Yet once subjects have consumed enough of the sweet stuff, the midanterior site shuts down, rendering the experience no longer pleasurable.

Further evidence that the midanterior site is important for human pleasure comes from studies of therapeutic deep-brain stimulation. The procedure is being used to treat a few conditions, including to relieve suffering in patients with otherwise untreatable chronic pain. In one patient of ours, an amputee who was feeling pain in his missing limb, stimulation of an area within the brain stem not only relieved the pain but induced deep feelings of pleasure. Simultaneous neuroimaging revealed a burst of activity in the midanterior site as well. Whether such stimulation of specific hotspots in the pleasure system can be used to treat depression or other forms of anhedonia—an inability to experience pleasure—remains an active area of investigation.

Similarly, additional research may reveal how the circuits that govern pleasure and reward are linked. Under normal circumstances, the hedonic hotspots are coupled with the dopamine-driven reward system, such that we desire things that make us feel good and avoid or are indifferent to things that do not. In the case of addiction, these systems somehow become disconnected, causing the individual to continue to crave things that no longer bring pleasure. Such dissociation might also possibly contribute to other types of compulsive behaviors, such as binge eating and gambling. Understanding how and why such uncoupling can occur could reveal better ways to reverse the brain changes that drive addiction, thus restoring the natural alignment between wanting and liking.

Aristotle once observed that happiness consists of two key ingredients: *hedonia,* or pleasure, plus *eudaimonia*—a sense of meaning. Although scientists have made some progress in uncovering the biological basis of *hedonia,* we know very little about how the brain gives rise to a broader sense of a life well lived. We hope, however, that with time this puzzle, too, can be solved and that the discoveries will help people unite pleasure and purpose, elevating everyday experiences to something truly satisfying, perhaps even sublime. SA

Morten L. Kringelbach is director of Hedonia: TrygFonden Research Group at the University of Oxford and Aarhus University in Denmark. He serves on *Scientific American*'s board of advisers.

Kent C. Berridge is James Olds Collegiate Professor of Psychology and Neuroscience at the University of Michigan.

MORE TO EXPLORE

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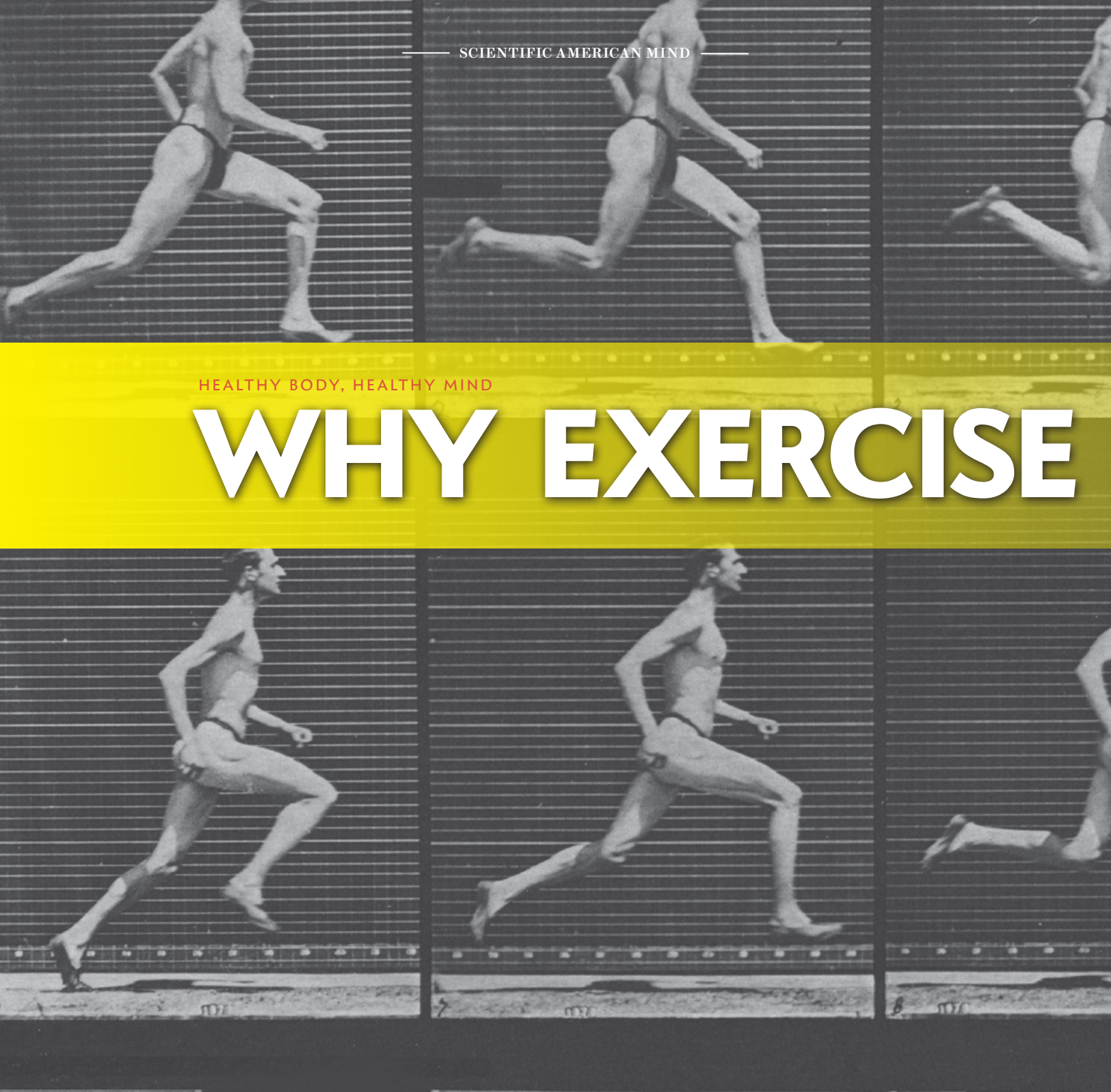
HEALTHY BODY, HEALTHY MIND

WHY EXERCISE



FIRST STEPS: In the 1800s Eadweard Muybridge perfected stop-motion photography to study human locomotion.

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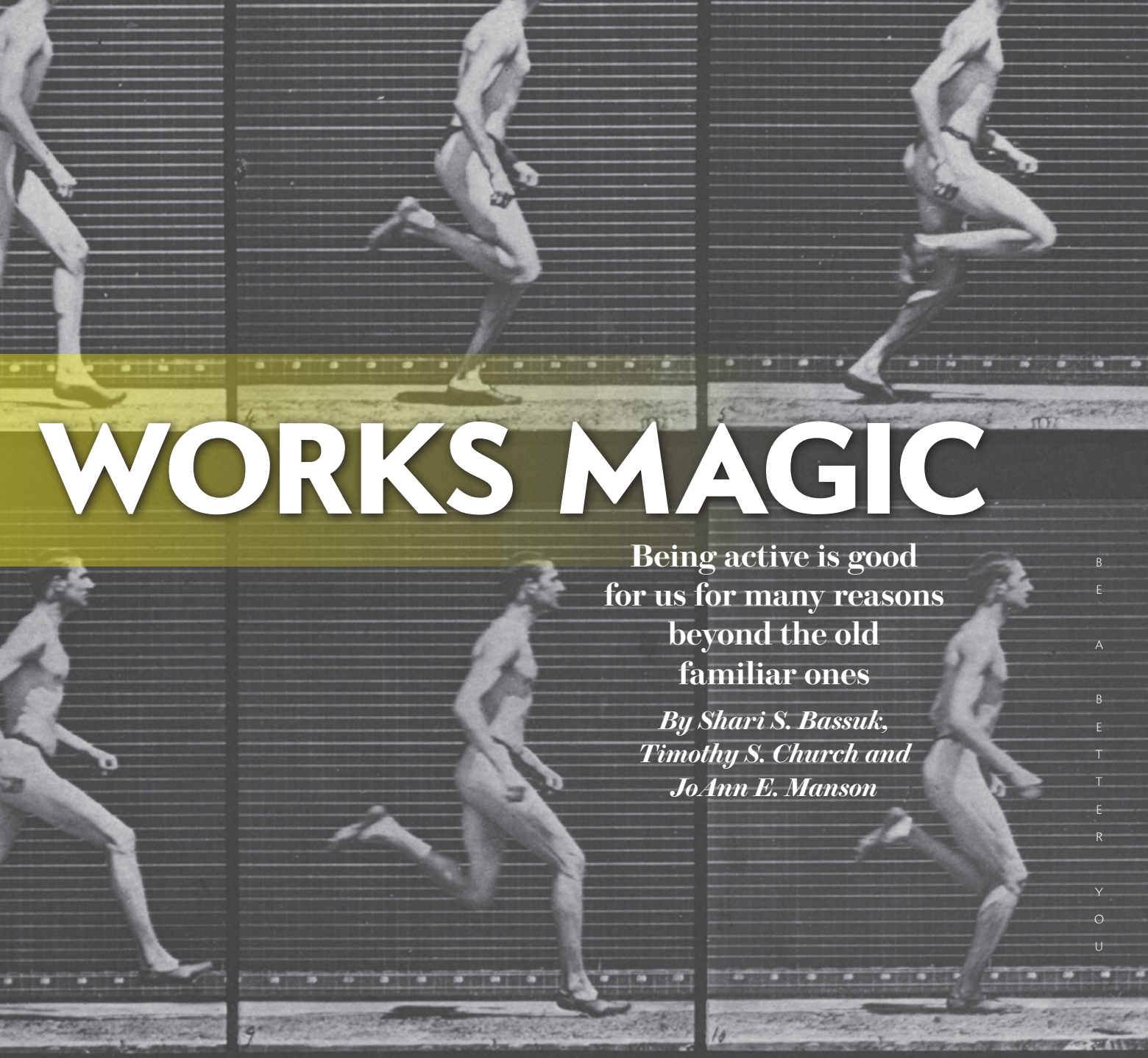
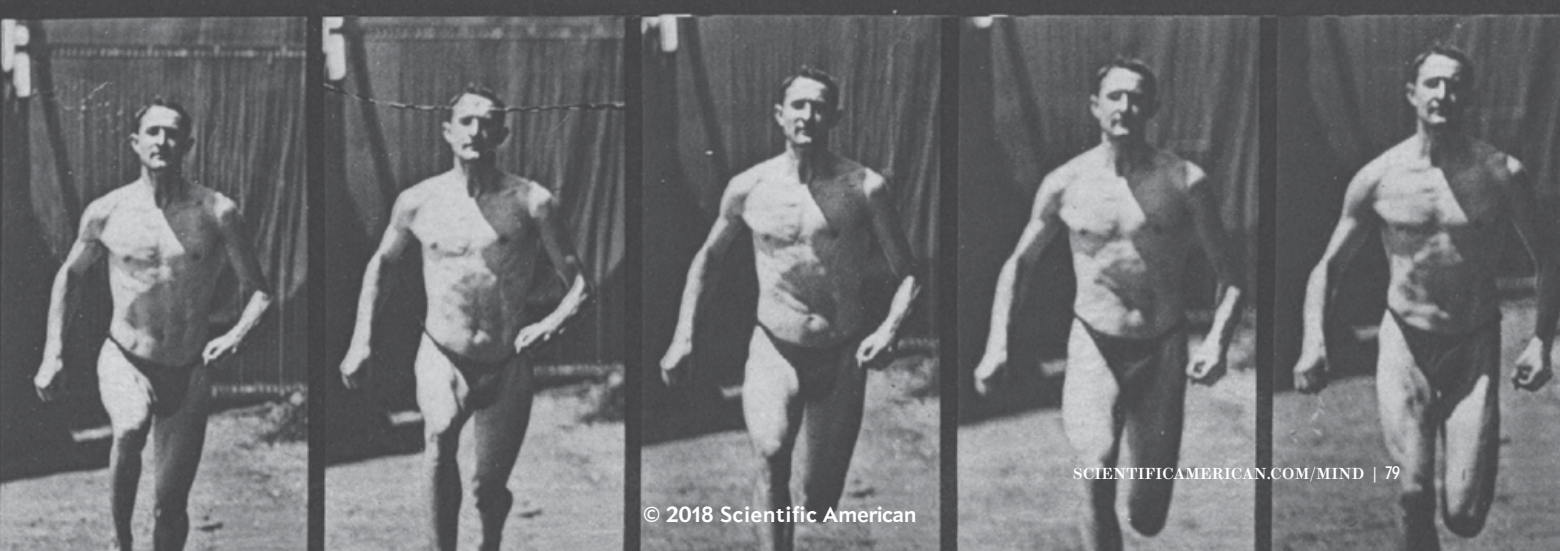


WORKS MAGIC

Being active is good for us for many reasons beyond the old familiar ones

By Shari S. Bassuk, Timothy S. Church and JoAnn E. Manson

BE A BETTER YOU



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WE ALL KNOW WE SHOULD EXERCISE. BUT FEW REALIZE THAT BEING physically active is the single most important thing that most of us can do to improve or maintain our health. Regular movement not only lowers the risk of developing or dying from heart disease, stroke and diabetes, it also prevents certain cancers, improves mood, builds bones, strengthens muscles, expands lung capacity, reduces the risk of falls and fractures, and helps to keep excess weight in check. And those are just some of the more familiar effects.

An explosion in research over the past half decade has extended those observations even further. Among other things, exercise appears to boost brainpower—specifically the ability to carry out tasks that require attention, organization and planning, reduce symptoms of depression and anxiety in some people, and enhance the immune system's ability to detect and fend off certain types of cancer. In addition, researchers are moving beyond describing the overall health benefits of regular physical movement to detailing the positive changes that occur at the level of cells and molecules for specific conditions such as atherosclerosis and diabetes.

Studies aimed at tracing the many ways, large and small, that various systems in the human body (cardiovascular, digestive, endocrine and nervous, to name just a few) are affected by exercise show that the benefits most likely result from minor to moderate improvements in many aspects of physiology, as opposed to large favorable effects on a small number of processes, in particular cells and tissues.

Investigators have also come to realize that people need not be triathletes to reap exercise's benefits. Twenty years ago preventive health experts focused almost exclusively on the gains to be had from vigorous activity. Today they emphasize the value of sustained bouts of moderate movement as well. One of us (Manson) helped to demonstrate comparable benefits of moderate and vigorous exercise for several health outcomes in the large-scale Nurses' Health Study and the Women's Health Initiative. Based on data from these and other projects, the latest U.S. exercise guidelines (published in 2008) recommend the equivalent of at least 30 minutes of moderate activity, such as brisk walking, five or more days a week (or 75 minutes of vigorous activity, such as jogging, each week), plus 30 minutes of muscle-strengthening activity at least two days a week.

A closer look at some of the most exciting findings offers a taste of the less obvious ways that exercise protects our body and keeps it running well.

IMMEDIATE EFFECTS

TO FULLY GRASP the latest findings, it helps to know something about how the body generally responds to increased physical demands. Exercise means different things to different people. From snowshoeing to swimming to a fast walk on the beach, exercise can take many forms and occur at differing levels of intensity. Aerobic exercise is the type that significantly boosts the amount of oxygen needed by the muscles, requiring the lungs to work harder. Its health benefits are also the best understood. But more stationary forms of exercise—such as lifting weights or practicing one's balance—also have their place.

Scientists have developed fairly rigorous methods for measuring the intensity of aerobic exercise in research laboratories. An effective and much less expensive way to measure how much you are pushing your body outside the lab is the talk test. Moderate activity begins when your heart starts beating faster

IN BRIEF

Routine physical activity of moderate or vigorous intensity substantially reduces the risk of dying from heart disease, stroke, diabetes, cancer and other ills.

Investigators have recently identified numerous previously unknown ways in which habitual exercise can reduce the risk of heart disease and cancer, can help control diabetes and can even facilitate learning.

Prolonged sitting may, however, cancel some of the health advantages gained through regular exercise.

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and you are breathing more heavily. You are still at a moderate level if you can talk or recite a poem while you are moving. If you can croak out only a word or two at a time, then you are exercising vigorously. At the other end of the scale, if you can sing while moving, then you are working at a light level of intensity.

Whenever a person picks up the pace, the nervous system prepares all the body's organs for action. Initially the individual may notice a heightened sense of awareness, increased heart rate, quickened breathing and light sweating. Internally, blood flow is reduced to those organs, such as the gastrointestinal tract and kidneys, that are not essential for movement. At the same time, blood vessels in the active muscles open up, ensuring that enough oxygen-rich blood flows to those muscles that are working the most.

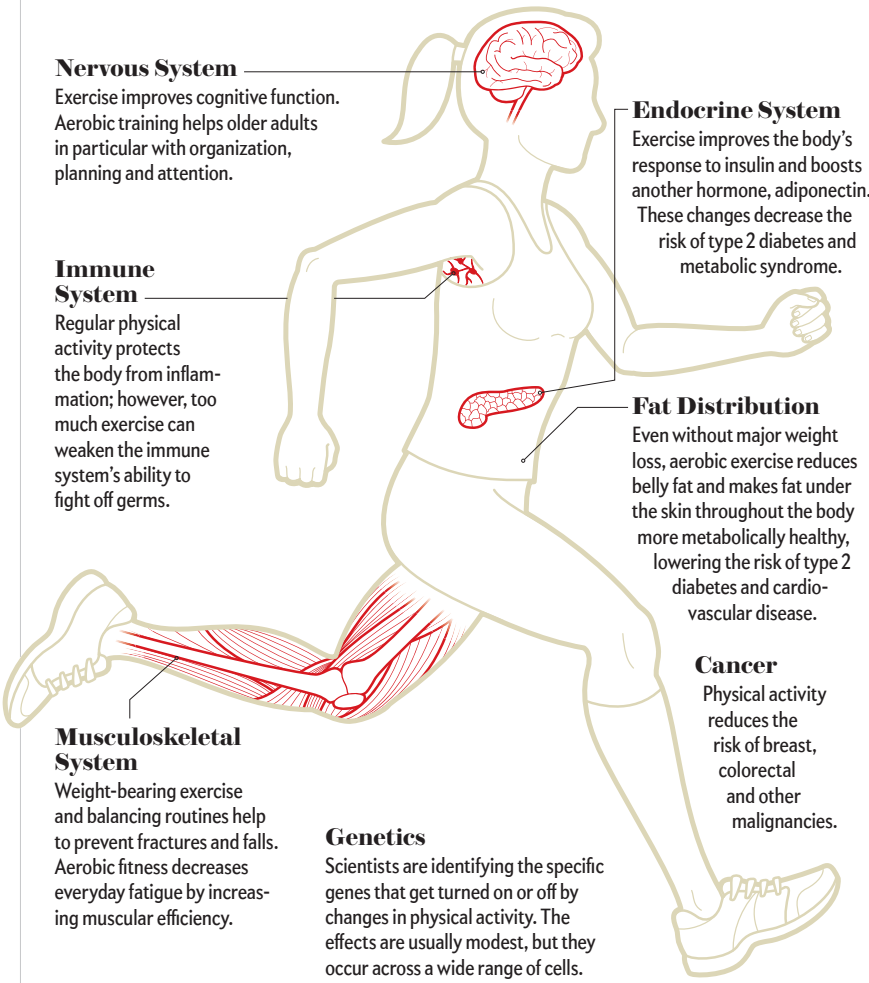
Once in the muscle cells, oxygen diffuses into cellular structures called mitochondria, which use it to generate energy for the cell. The basic fuel for this process is the sugar molecule glucose, which the body creates through the breakdown of larger food particles and absorbs during the course of digestion. The addition of oxygen to glucose in mitochondria triggers a highly efficient kind of combustion. When oxygen is available, mitochondria can create nearly 20 times more energy per glucose molecule than they can in the absence of oxygen.

The body first burns up glucose molecules that are stored in the form of a compound called glycogen, found primarily in the liver and muscles. But as exercise continues, the available stock of glycogen is depleted, and molecules of triglyceride (which is a kind of fat) become the chief source of fuel. All this internal combustion produces certain by-products, such as lactic acid and carbon dioxide, which seep from the muscles into the bloodstream, where they are sensed by the rest of the body. The increasing concentration of these wastes prompts further biochemical reactions in the brain, lungs and heart that eventually make removal of these compounds more efficient and less tiring.

The benefits of exercise really start to accumulate once physical activity becomes a routine habit. The body adapts to the increasing demands being placed on it, leading to increased stamina as individuals become more fit. For instance, the lungs process more oxygen as each breath becomes deeper and the heart pumps more blood with each beat. These adaptations, which typically begin to show up within a few weeks of meeting or exceeding the federal guidelines on physical activity, also lead to changes in biology that improve long-term health.

Exercise Benefits Even Obscure Parts of the Body

Most people do not realize that sustained bouts of moderate to vigorous physical activity completely change our bodies from the inside out. Here is a look at a few of the less widely known effects, starting with the neural connections in the brain and extending all the way out to the major muscles and bones of the limbs.



Nervous System
Exercise improves cognitive function. Aerobic training helps older adults in particular with organization, planning and attention.

Endocrine System
Exercise improves the body's response to insulin and boosts another hormone, adiponectin. These changes decrease the risk of type 2 diabetes and metabolic syndrome.

Immune System
Regular physical activity protects the body from inflammation; however, too much exercise can weaken the immune system's ability to fight off germs.

Fat Distribution
Even without major weight loss, aerobic exercise reduces belly fat and makes fat under the skin throughout the body more metabolically healthy, lowering the risk of type 2 diabetes and cardiovascular disease.

Cancer
Physical activity reduces the risk of breast, colorectal and other malignancies.

Musculoskeletal System
Weight-bearing exercise and balancing routines help to prevent fractures and falls. Aerobic fitness decreases everyday fatigue by increasing muscular efficiency.

Genetics
Scientists are identifying the specific genes that get turned on or off by changes in physical activity. The effects are usually modest, but they occur across a wide range of cells.

MOLECULAR CHANGES

ENTIRE LIBRARIES could be packed with data demonstrating the effects of exercise on everything from major organ systems to how various genes are turned on or off. A few top-level conclusions are outlined in the infographic that accompanies this article [*see box above*]. But we will focus here on some of the newly discovered mechanisms that help to explain why exercise expands our cognitive capacities, improves our ability to con-

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trol blood glucose levels and strengthens our cardiovascular system. These changes have a greater effect on the quality of daily life than almost any other exercise benefits.

Athletes have long known that exercise boosts their mood and mental health. And yet it was not until 2008 that scientists were able to directly measure the so-called runner's high—a sense of euphoria that occurs after prolonged exercise. Not only did they show that the brain released more endorphins (opioid-like hormones that evoke pleasurable feelings) during a long-distance run, they also determined that the compounds were active in regions of the brain responsible for strong emotions. (Previous work had detected an endorphin surge only in the bloodstream, which was unrelated to changes in the brain.)

More recently, investigators have focused on the chemical changes in the brain by which exercise enhances our ability to concentrate, think and make decisions. In 2011 a randomized controlled trial of 120 people in their 60s and 70s demonstrated that exercise increases the size of a part of the brain called the hippocampus. The study's authors noted that the specific portion of the hippocampus that was affected by exercise is one that allows people to remember familiar surroundings; it is also one of the few areas of the brain that makes new nerve cells—at least in rats. Newborn neurons are thought to help with distinguishing similar but different events and things. Animal studies have further shown that exercise increases the levels of the chemical responsible for triggering the growth of these new neurons—a molecule known as brain-derived neurotrophic factor, or BDNF. Most recently, animal studies have identified a protein produced in the hippocampus that is responsible for increasing BDNF expression and turning on genes related to cognition. Researchers are hoping to develop an injectable form of this protein, called irisin, that could eventually be used to boost brain-protecting pathways.

REGULAR PROLONGED MOVEMENT—AT WHATEVER INTENSITY LEVEL CAN BE SAFELY MANAGED—SHOULD BE BUILT INTO EVERYONE'S DAILY HABITS AND PHYSICAL ENVIRONMENT.

Now research is challenging what we thought we knew about how exercise prevents heart disease. Scientists initially believed that routine activity reduced cardiovascular risk largely by decreasing blood pressure and lowering the amount of LDL cholesterol (also known as the bad cholesterol) while raising the amount of HDL cholesterol (the good cholesterol) in the blood. This conclusion was only partly correct. Exercise does in fact lower blood pressure substantially for some individuals, but for most people this benefit of exercise is relatively small. Moreover, exercise—particularly resistance exercise, such as weight training—can raise HDL cholesterol, a change that typically takes several months to emerge, although the effect is fairly modest—on the order of a few percentage points.

Further investigation has shown that the more important LDL-related effect has to do with how exercise changes the molecule's properties as opposed to reducing the amount found in the blood. Technically speaking, LDL is not synonymous with cholesterol; rather it carries cholesterol through the bloodstream the way a delivery truck carries groceries. (Being made of fat, cholesterol cannot dissolve in the watery environment of the bloodstream, so it has to be packaged in something that can.) LDL particles also come in various sizes in the same way that groceries can be delivered in minivans or giant trucks.

Over the past several years a growing number of scientists have found that smaller LDL molecules are particularly dangerous. They have a tendency, for example, to lose electrons, which then ricochet around the blood vessels damaging other molecules and cells (think crazed driver behind the wheel of a beat-up van). Large LDL molecules, on the other hand, are much more stable and float through the bloodstream without crashing into anything (more akin to big, well-maintained trucks with professional drivers).

Studies now show that exercise increases the number of larger, safer LDL molecules while decreasing the number of small, dangerous ones, and it alters the ratio by boosting the activity of an enzyme called lipoprotein lipase in fat and muscle tissue. Two people with the same amount of cholesterol in their blood but different levels of physical activity could thus have very different risk profiles for cardiac disease. The couch potato would probably have a lot of small LDLs and very few if any large ones, whereas large LDL molecules would predominate in the active person's blood. And yet despite having an identical cholesterol level, the first person would have several times the risk of suffering a heart attack as the second person.

Regular physical activity positively affects another key component of the blood—the sugar glucose. The liver, pancreas and skeletal muscles normally work together seamlessly to make sure that each part of the body gets the sugar it needs, whether you are at rest or active. By definition, exercise places increased demands on the skeletal muscles, which need increasing amounts of glucose to fuel their efforts. Over the long term, exercise also prompts the fibers within the muscle to become more efficient at using glucose, making the muscle stronger.

The liver responds immediately to the call for more fuel by churning sugar molecules into the bloodstream, and the pancreas releases a hormone called insulin that signals the cells to draw increasing amounts of glucose out of the blood. You might imagine that the whole process could lead to wild swings in glucose levels, but the body works hard to keep its blood sugar levels within a fairly limited range of between 70 and about 140 milligrams per deciliter (and well below 126 mg/dL in the fasting state)—at least in folks without diabetes. One reason that blood sugar needs to stay above 70 mg/dL is that the brain depends heavily on glucose as its primary source of fuel and thus is acutely sensitive to any change in the amount found in the blood. Although extremely low glucose levels can lead to coma and death in a matter of minutes, it is just as important not to spend long periods at the high end of the scale. Broadly

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speaking, extra sugar in the blood tends to gum up the works, causing cells to age prematurely.

As exercise becomes more of a daily habit, the muscles grow more sensitive to the effects of insulin. That means the pancreas does not have to work as hard to help keep glucose levels in check; lower levels of insulin will accomplish the same result as higher amounts once did. Doing more with less insulin is particularly helpful for people with type 2 diabetes, whose bodies have trouble keeping blood sugar in the normal range, in large part because they have become resistant to the hormone's effects. But insulin also promotes the proliferation, or rapid production, of new cells—and as such, elevated levels have been linked to a greater risk for developing breast and colon cancer in particular.

Recently physical activity has also been shown to promote the uptake of glucose through another pathway that does not require the presence of insulin. Having a second pathway to get glucose out of the bloodstream and into the muscle cells could open up new directions in the treatment of diabetes.

Intriguingly, the greatest benefits for people with diabetes seem to come from mixing different types of exercise. Two large randomized clinical trials have reported the combination of aerobic and resistance exercise is better at controlling blood glucose levels than either type of exercise alone. The first study was conducted in such a way, however, that it was unclear if the benefit came from the combination of exercise types or the fact that participants who underwent aerobic and resistance training also ended up exercising longer than their counterparts who followed a single exercise program. One of us (Church) decided to tackle that question by leading a second trial in which 262 previously sedentary men and women with diabetes were divided into four groups: an aerobic exercise group (who walked on a treadmill), a resistance group (seated rowing, leg presses, and the like), a combination group, and the control group, which undertook weekly stretching and relaxation classes.

Each of the groups who engaged in physical activity expended the same amount of time and effort (approximately 140 minutes per week) over the course of nine months. They also all lost inches off their waist, and both groups that performed aerobic exercise became more fit. But only the group that undertook both resistance and aerobic exercises exhibited a significant drop in their blood in the amount of a protein called HbA1c, which acts as an indicator of average blood glucose level over the past several months. The additive benefit suggests that aerobic and resistance training operate through different physiological mechanisms—an idea that investigators are actively pursuing.

Another way that continued exercise strengthens muscles is by boosting the formation of energy-producing mitochondria. In response to regular exercise, muscle cells start making a protein called PGC-1α, which directs the cells to churn out new mitochondria. More mitochondria mean each cell can convert more glucose into energy.

SITTING HAZARD

GIVEN THE MULTIPLE health benefits of moderate exercise, you might expect that everyone is lacing up their walking shoes and heading out the door. But many Americans fail to achieve even the recommended half an hour of moderate activity on five or more days of the week. Only 52 percent of U.S. adults are active enough to meet the aerobic exercise guideline, and 29 percent strengthen their muscles as recommended twice a week for 30 minutes at a time. One in five Americans meets the recommendations for both aerobic and resistance exercise.

The difficulties of changing people's sedentary habits have prompted scientists to investigate whether lighter or shorter bouts of exercise have any health benefits. Positive results, they hope, might motivate even couch potatoes to start moving more than they are used to doing. So far the data suggest that even minimal daily exercise routines can extend people's lives somewhat. A 2012 analysis of the data from six studies, totaling 655,000 adults in the U.S. who were tracked for about 10 years, found that people who expended as little as 11 minutes per day on leisurely activities (gardening, washing the car, taking an evening stroll) had a 1.8-year longer life expectancy after age 40 compared with their inactive peers. Admittedly, participants who met recommended guidelines for moderate activity were better off; their life expectancy was 3.4 years longer. And those who were active between 60 and 90 minutes each day achieved even greater gains (4.2 years longer life expectancy).

Despite the advantages of minimal efforts, a comprehensive look at exercise studies to date shows that most people would benefit from ramping up their activity—for example, adding moderate activity if they are light exercisers or short bursts of vigorous activity if they are moderate exercisers. Perhaps the worst news for today's office-bound knowledge workers is that sitting for more than six hours a day during leisure time may prove harmful even if you also manage a few high-intensity workouts. Still unknown: whether it is something about sitting itself that is a problem or the lack of movement usually associated with it.

Given the continual and growing evidence for the health benefits of physical activity, the message is clear. Regular prolonged movement—at whatever intensity level can be safely managed—needs to be built into everyone's daily habits and physical environments. It should become as easy as jumping into a car is now.

We strongly recommend that doctors and other health care providers regularly write a prescription for exercise during routine office visits. In addition, we advocate for increased research into the kinds of behavioral programs, public health campaigns and changes in urban design that will facilitate sustained levels of beneficial physical activity in our largely sedentary society. SA

Shari S. Bassuk is an epidemiologist at Brigham and Women's Hospital.

Timothy S. Church is director of the preventive medicine research laboratory and professor at the Pennington Biomedical Research Center at Louisiana State University and chief medical officer at ACAP Health.

JoAnn E. Manson is chief of the division of preventive medicine at Brigham and Women's Hospital, professor of medicine and Michael and Lee Bell Professor of Women's Health at Harvard Medical School, and professor in the department of epidemiology at the Harvard School of Public Health.

MORE TO EXPLORE

The Brain-Body Connection: GCBH Recommendations on Physical Activity and Brain Health. Global Council on Brain Health (AARP), 2016.

Physical Activity Guidelines. Information from the Office of Disease Prevention and Health Promotion: www.health.gov/paguidelines

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HEALTHY BODY, HEALTHY MIND

SLEEP ON IT!

Your nightly rest turns out to affect your mind and health more than anyone suspected

By Robert Stickgold

"Do I really need to sleep?"

As I travel around the world talking about sleep, I am asked this question over and over. The answer has always been clear—yes, everyone needs to do it. Just like hunger, thirst and sexual desire, the urge to sleep is a physiological drive. Exactly what spending a third of our lives unconscious gets us, however, has long mystified scientists.

Illustration by Maria Corte Maidagan

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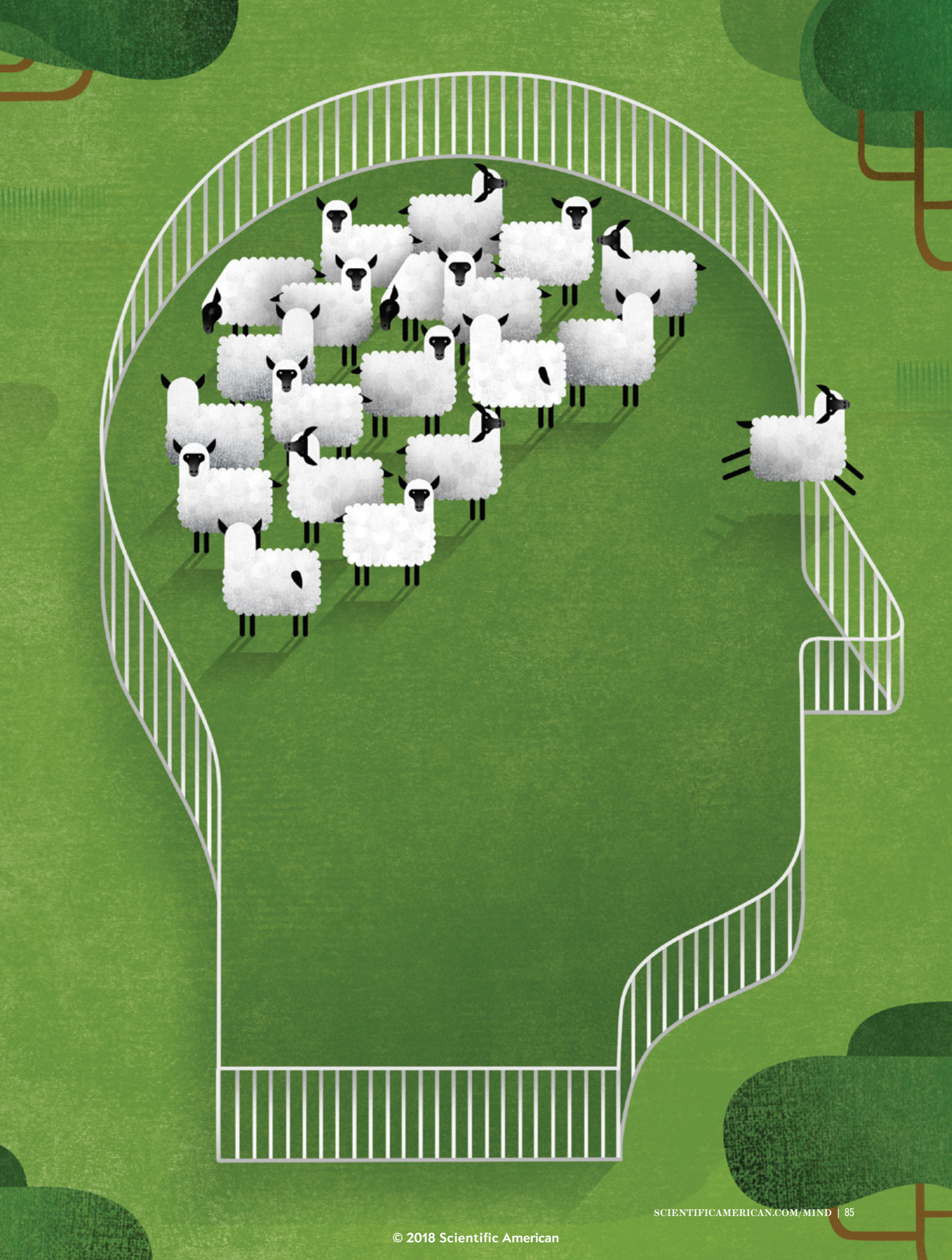

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In acknowledging our lack of an answer, Allan Rechtschaffen, one of the world's foremost sleep researchers, said in 1978, "If sleep does not serve an absolutely vital function, then it is the *biggest mistake* the evolutionary process has ever made" (emphasis mine). In the 1990s J. Allan Hobson, another leading sleep researcher, quipped that the only known function of sleep was to cure sleepiness.

Research over the past 20 years has finally begun to provide at least a partial explanation for why we must sleep. The clearest finding is that sleep does not serve just a single purpose. Instead it appears to be needed for the optimal functioning of a multitude of biological processes—from the inner workings of the immune system to proper hormonal balance, to emotional and psychiatric health, to learning and memory, to the clearance of toxins from the brain. At the same time, none of these functions fails completely in the absence of sleep. In general, sleep seems to *enhance* the performance of these systems instead of being absolutely necessary. And yet anyone who lives for months without sleep will die.

Even this imperfect understanding has taken decades to develop. By the end of the 20th century researchers had replaced ancient notions about sleep—that it was caused by blood retreating from the surface of the skin or by the buildup of warm vapors from the stomach—with detailed measurements of brain-wave activity, breathing patterns, and daily oscillations in the amount of hormones and other molecules in the blood. More recently, investigators have begun identifying the exact aspects of sleep that are important for each of its benefits. Ironically, though, the more researchers uncover about the unconditional necessity of a good night's sleep for the proper functioning of mind and body, the less time 21st-century citizens spend in the soothing arms of Morpheus, the Greek god of dreams.

FATAL INSOMNIA

THE CLEAREST EVIDENCE of our absolute need for sleep comes from a study published in 1989 by Carol Everson based on work she did while at Rechtschaffen's laboratory at the University of Chicago. Everson, now at the Medical College of Wisconsin, found that rats totally deprived of sleep all died within a month. In actuality, all she had to do to achieve this fatal result was to prevent the animals from entering the stage of sleep characterized by rapid eye movement (REM). But a quarter of a century later researchers still cannot explain *why* the rats died. A series of experiments in the intervening years has only served to eliminate possible causes; it is not caused by, for example, increased stress, excessive energy consumption, or failure of the body's internal heat regulators or the immune system.

Death by sleep deprivation is not unique to rats. Fatal familial insomnia, first described about 30 years ago, is, as the name suggests, a heritable human disorder that leads first to unremitting insomnia and thence to death. A team of Italian researchers, then at the University of Bologna's medical school, reported it in 1986. The group, led by the late Elio Lugaresi and Rossella Medori, told the story of a 53-year-old man who died within months of developing intractable insomnia—as had many of his relatives over two generations. Postmortem analysis of his brain showed massive loss of nerve cells in two regions of the thalamus, a structure about the size of a walnut that is found in the midbrain and generally acts as a way station for incoming sensory input. The two particular regions in question, however, are known more for their role in regulating emotional memory and producing so-called sleep spindles, a key pattern of waves found in electroencephalograms of the sleeping brain.

How this deterioration in the thalamus might lead either to insomnia or to death is unclear. But the immediate cause of the damage itself is now known. In the early 1990s Medori, by then at Case Western Reserve University, and her colleagues determined that a malformed protein, called a prion, was responsible for the destruction. Prions are also known to cause scrapie in sheep and bovine spongiform encephalopathy ("mad cow disease") in humans—though in the case of fatal familial insomnia, the prion is inherited from one generation to the next rather than being ingested from the environment, as in the other two ailments.

Fortunately, there are no other reported instances of human death caused by sleep deprivation (aside from accidental deaths when, for example, a sleepless driver falls asleep at the wheel). But there are also no other reports of people going several months without sleep. We are thus left with two examples of prolonged and total sleep deprivation leading to death—experimentally induced sleep deprivation in rats and a heritable prion disease in humans—and with no understanding of the exact cause of death in either case.

ANTIBODIES AND HORMONES

MEANWHILE WE DO KNOW that as little as one night of complete or even partial sleep loss can interfere with various bodily functions, such as hormonal activity and protection against infections. Two studies looking at the body's response to immunization with hepatitis vaccines show how dramatic the effects of sleep deprivation can be on the immune system. In the first experiment, from 2003, a small group of college students received a standard hepatitis A vaccination consisting of inactivated virus in the morning, after which investigators permitted half of them to sleep normally; the other half were kept awake all night.

The sleep-deprived subjects were not allowed any sleep until the following night. Four weeks later researchers took blood samples from the students and measured the amount of protective antibodies that their immune system had produced in response to the virus in the vaccine. Higher levels of antibodies would indicate a better response to the vaccine and thus likely

IN BRIEF

Many studies—not to mention common experience—support the link between a good night's sleep and improved mood, memory and learning.

A growing number of experiments carried out over the past two decades have also found that the mechanism of sleep directly affects other workings of the body, from hormonal balance to immune protection.

Despite these findings, researchers still do not understand exactly why we need our daily visit to the land of Nod, but they are learning a great deal about what precisely happens physiologically when we sleep.

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greater protection against future infection with disease-causing versions of the virus. After the four weeks, the group that had enjoyed a normal night's sleep had 97 percent higher antibody levels than the one that had been sleep-deprived.

Negative effects are measurable with less than a full night's sleep as well. In the second study, adults received the standard three doses of hepatitis B vaccine over the course of six months. (Repeat vaccination is required to build up full immune protection.) Researchers gave each participant a motion detector similar to a watch, which monitored their sleep at home. By comparing the subjects' average amount of sleep during the week of their first shot to the level of antibody protection they displayed after the second shot, investigators determined that antibody levels increased 56 percent for every additional hour of sleep. Six months after the final vaccination, those who had averaged less than six hours of sleep a night during the week around the first vaccination were seven times more likely to have such low amounts of antibodies in their blood that they were considered unprotected against future infection with the hepatitis B virus.

Even otherwise healthy children with sleep disturbances show immune deficits. In 2017 Zihe Zhang of Shandong University in China and colleagues examined the immune status of 50 children with obstructive sleep apnea. Based on changes in the concentrations of T lymphocytes and other immune-related indices in their blood, the researchers concluded that sleep apneas led to impaired immune function in these children.

Impressive evidence for impaired hormonal function came from a series of studies performed by Karine Spiegel, who was at that time working with Eve Van Cauter of the University of Chicago. In one of these experiments, researchers allowed 11 healthy young men to get just four hours of sleep a night. After five nights of restricted sleep, the men's ability to clear glucose from the blood—a process that the hormone insulin manages—was reduced by 40 percent. In a separate study, Spiegel and her colleagues similarly limited the amount of sleep of 12 men for two nights. The scientists measured the amount of ghrelin, an appetite-stimulating hormone, found in the volunteers' blood and found it had jumped by 28 percent. At the same time, amounts of a different hormone, known as leptin, decreased by 18 percent; leptin inhibits hunger by signaling the brain that there is no need to eat. Not surprisingly, the sleep-deprived men reported an average 23 percent increase in their hunger levels.

Taken as a whole, these studies of human physiology suggest that reduced sleep could lead to increased weight gain—a hypothesis that is now supported by at least 50 other studies. In several investigations, children from six to nine years of age who got fewer than 10 hours of sleep were one and a half to two and a half times more likely to be obese, and studies in adults suggest a 50 percent increase in obesity among participants with fewer than six hours of sleep. Research also shows an association between sleep restriction and the development of type 2 diabetes.

NEGATIVITY BOMB

DESPITE THE REMARKABLE EFFECTS of restricted sleep on immune and hormonal function, its greatest impact probably occurs in the brain. In a 2006 study I conducted with Matthew P. Walker, now at the University of California, Berkeley, we looked at how a single night of sleep deprivation affected the emotional memories that people laid down. Twenty-six subjects—half of whom had been sleep-deprived the night before—were shown positive, negative and neutral words (for example, "calm," "grief" or "willow") and asked to rate their emotionality. Then, after two

Don't Skimp on Sleep

Research has uncovered many ways that sleep deprivation impairs mental and physical health. Some of the best-studied and most significant impacts are highlighted here.

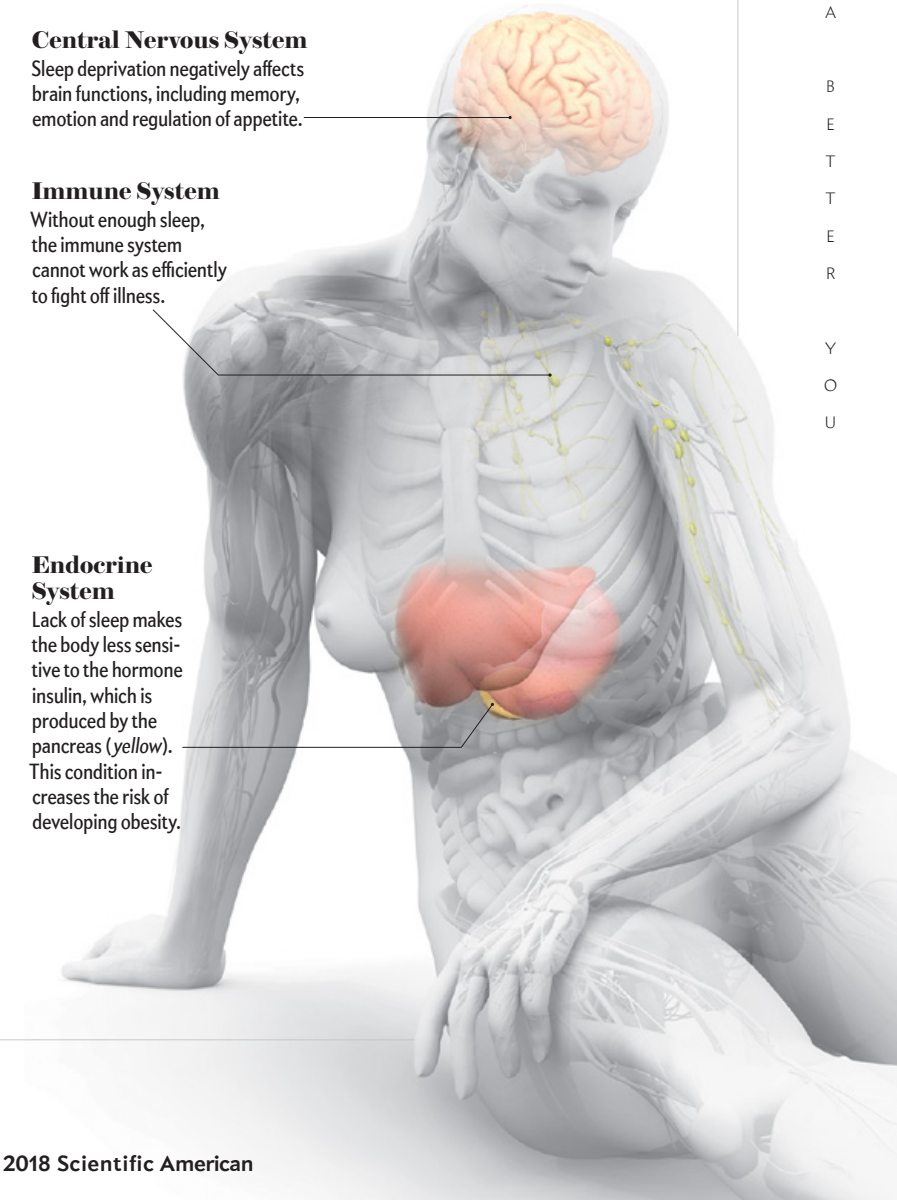
Central Nervous System
Sleep deprivation negatively affects brain functions, including memory, emotion and regulation of appetite.
Immune System
Without enough sleep, the immune system cannot work as efficiently to fight off illness.
Endocrine System
Lack of sleep makes the body less sensitive to the hormone insulin, which is produced by the pancreas (*yellow*). This condition increases the risk of developing obesity.

Illustration by Bryan Christie Design

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nights of recovery sleep, they were given a surprise memory test.

Compared with the subjects who had slept normally, those who were sleep-deprived before seeing the words for the first time showed a 40 percent deterioration in their ability to recognize them. But more striking was the relative impact of sleep deprivation on the three categories of words. When subjects were sleep-deprived, their recognition of positive and neutral words both deteriorated by 50 percent. Their ability to recognize words with negative connotations, however, deteriorated only 20 percent. In contrast, the memory formed after normal sleep for positive and negative words differed little, with neutral words being less memorable than either positive or negative words. In other words, the memory of negative words appeared to be at least twice as strong as positive or neutral words after study volunteers were forced to cut back on their sleep.

This result suggests the rather horrifying possibility that when you are sleep-deprived, you effectively form twice as many memories of negative events in your life as of positive events, producing a biased—and potentially depressing—memory of your day. Indeed, several studies over the past 25 years have now concluded that poor sleep can, under certain circumstances, lead to depression severe enough to be diagnosed as major depression and may contribute to other psychiatric disorders as well.

WHEN YOU ARE SLEEP-DEPRIVED, YOU FORM TWICE AS MANY MEMORIES OF NEGATIVE EVENTS IN YOUR LIFE AS OF POSITIVE EVENTS.

The evidence of a causal link with depression in particular has grown in recent years and comes to a large extent from studies of sleep apnea, a disorder in which the flow of air into the lungs becomes interrupted during sleep. It may lead to snoring, gasping and other disruptions of respiration. Each time individuals with sleep apnea briefly stop breathing, they awaken momentarily to start breathing again. As a result, sufferers of severe apnea might wake up every minute or two throughout the night. A 2012 study by the U.S. Centers for Disease Control and Prevention found that men and women with a diagnosis of sleep apnea are, respectively, 2.4 and 5.2 times more likely to have major depression compared with their better-rested counterparts.

Of course, finding a correlation between these two conditions is not the same thing as proving that one causes the other. But a recent analysis of 19 studies found that treating sleep apnea with so-called CPAP devices (for *c*ontinuous *p*ositive *a*irway *p*ressure), which restore normal breathing and sleep, significantly reduces symptoms of depression. Indeed, one of the studies, which coincidentally had included a greater percentage of depressed patients at the outset than the others, found a 26 percent reduction in depression symptoms in CPAP users.

These results still do not prove conclusively that fitful sleep can bring on depression, nor was the effect of the CPAP treatment compared with that of antidepressant medication. Nevertheless, these suggestive findings deserve further investigation. Similarly, a 2007 study found that treatment of apnea in children who also had attention-deficit/hyperactivity disorder led to a 36 percent decrease in hyperactivity symptom ratings—a significantly larger reduction than the 24 percent achieved with typical ADHD medications.

FUTURE MEMORIES

ALTHOUGH RESEARCHERS still do not know the physiological mechanism by which sleep and its lack affect mental health, they suspect that the role sleep plays in helping the brain transform people's daily experiences into memories has a lot to do with it. The past two decades have seen an explosion of discoveries showing that sleep participates in memory processing in everyone—no matter what their emotional state. Among the findings: sleep after learning leads to the selective stabilization, strengthening, integration and analysis of new memories. In doing so, it controls what we remember and how we remember it.

In the late 19th and early 20th century scientists considered memories to be fragile until they went through a process of so-called consolidation, which transformed them into a stable form that could last a lifetime. More recent research has shown that memories retain the ability to change even after the brain records and consolidates them. Indeed, reactivation of a memory can return it to an unstable state long after it was first formed, requiring reconsolidation; while in this labile form, it can be changed or lost altogether. This finding is both a curse and a blessing—a curse because originally accurate information can be corrupted and a blessing because inaccurate information can be corrected. Researchers have thus begun to talk about memory *evolution* instead of memory consolidation, especially when discussing sleep-dependent memory processing.

The modern era of research into sleep and memory began just over 20 years ago, when Avi Karni and his colleagues in Israel demonstrated that subjects trained on a visual-discrimination task actually improved over a night of sleep but only if they were allowed to enter REM sleep. (As an aside, most dreams take place during REM sleep.) Their experiment showed that sleep does more than just stabilize memories, keeping them from deteriorating over time; it actually improves them.

In 2000 Walker came into my office waving a journal article and predicting, "This one is sleep-dependent, too!" The paper described a task in which subjects learned to tap out a particular sequence of finger movements, which became easier for them to do over time, even without additional practice. Still, the authors had not looked at how sleep might contribute to this improvement. Within two weeks Walker had the answer. He found that sleep had indeed improved their performance, and he later determined that the benefit depended on experiencing a light stage of non-REM sleep rather than of REM sleep, as in the Karni vision experiments. The inescapable conclusion: the brain strengthens different types of memories during different stages of sleep.

Further research showed that not all memories undergo this sleep-dependent stabilization. In 2008 Jessica Payne, now at the University of Notre Dame, conducted a study in which she showed volunteers various scenes with aversive objects—such as a dead cat in the middle of a road. She found that after a night of sleep the subjects could accurately recognize the image

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of the dead cat, but they had forgotten the background street scene. What was most impressive was that this selective forgetting of the background details did not happen when she trained subjects in the morning and then tested them in the evening after a day spent awake. And it did not happen if the central image was nonaversive—for example, if it was just a cat crossing the road. Thus, sleep, but not wakefulness, caused the brains of the study participants to retain the highly emotional central images in preference to either the neutral images (cat crossing the road) or their background scenes.

But it is not just emotional memories that are preferentially enhanced during sleep. It appears that anything you think is important will be selectively retained while you are asleep. Two groups in Europe have shown that telling subjects who have been trained on a particular task that they will or will not be tested on that information after they sleep affects what happens during that sleep. As you might expect, only the information that subjects are told they will be retested on shows improvement the next day. In contrast, when subjects are trained in the morning, informing them that they will or will not be tested that evening does not seem to make any difference. Sleep, then, and not wakefulness, selectively strengthens memories that the brain deems valuable.

These findings support the arguments of Daniel Schacter of Harvard University that memory is about the future, not about the past. He has argued that we have evolved memory systems not so we can reminisce about the past but so we can use prior experience to enhance our future performance. In this context, it is not surprising that sleep seems to care most about information that is likely to be of future relevance. When we talk about sleeping on a problem, we are not merely asking the sleeping brain to remember something. We want our brain to take the information that is already stored there and do some kind of calculation, to juxtapose different possibilities, to find the best solution to a problem. Lucky for us, it can!

An example of this analytic ability is highlighted in a weather-prediction experiment developed by Barbara J. Knowlton and her colleagues at the University of California, Los Angeles. Knowlton showed subjects one or more cards from a set of four—each of which displayed a particular geometric design (circles, diamonds, squares or triangles). Before the subjects began the task, the researchers assigned each card to a particular imaginary weather outcome—rainy or sunny—without sharing the information with the participants. Then, based on the cards shown, investigators asked those participants to predict whether the cards indicated the weather would be rainy or sunny. Over time subjects got a sense of how the cards related to the weather. For example, the first trial might show the diamonds card, and the weather, the subjects are told, turns out to be sunny. Then, on the second trial, the circles and triangles cards are both displayed, and the weather turns out to be rainy. Even after just these two trials, subjects inevitably would begin to construct hypotheses about the relations, such as that diamonds mean sunshine. But then, on the third trial, the diamonds card might appear again, only to be followed by rain.

The trick here is that the cards are only *probabilistically* related to the weather. Thus, the diamonds card predicts sun 80 percent of the time, but for the other 20 percent, it is followed by rain. Other cards end up predicting sun just 20 to 60 percent of the time. In Knowlton's study, even after 200 trials, subjects still had not mastered the task, guessing the most likely outcome only about 75 percent of the time.

Use of such tasks has allowed researchers to discriminate between different memory systems within the brain—those involved in remembering facts (the "what" system) and those involved in learning skills (the "how" system). As subjects train on the weather-prediction task, they slowly shift from using the *what* system to the *how* system. When Ina Djonlagic in my lab asked what happens to this information with sleep, she obtained an amazing result. When volunteers who had trained in the morning were retested the same evening, they also performed at around 75 percent, apparently fully retaining the information they had learned that morning. But when other subjects were trained in the evening and tested after a night of sleep, they were 10 percent better at predicting the outcome than they had been the evening before. Somehow the sleeping brain was actually able to improve participants' understanding of the relation between the cards and the subsequent weather. They had gained a better model of how the world worked.

The more researchers explore what happens while we sleep, the more they discover new benefits to a good night's sleep. The most recent possible addition to the list is the clearance of waste products from the brain. In 2013 Lulu Xie and her colleagues at the University of Rochester Medical Center reported that the space between cells in the brain increases during sleep, allowing for better flow of cerebrospinal fluid between the brain and the spine. When the investigators injected beta-amyloid (the precursor of the amyloid plaques found between neurons in Alzheimer's disease) into mice, they found that it was cleared from the brain during sleep at twice the rate seen in awake animals. Presumably the increased flow of cerebrospinal fluid helped to move the potentially toxic molecule out of the brain, away from the areas where it could cause the most damage. Now researchers would like to find out whether the increased flow normally seen during sleep is impaired in people who have Alzheimer's.

Given all the latest research on the many functions of sleep and the likelihood that yet more will be discovered, skimping on sleep is looking like a worse and worse strategy for dealing with the demands of daily life. Taken together, the results of studies looking at the role of sleep in hormonal, immunological and memory functions suggest that if you do not get enough, you could—besides being very tired—wind up sick, overweight, forgetful and very blue. SA

Robert Stickgold is director of the Center for Sleep and Cognition at Beth Israel Deaconess Medical Center and an associate professor at Harvard Medical School.

MORE TO EXPLORE

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HEALTHY BODY, HEALTHY MIND

mind of the meditator

Contemplative practices that extend back thousands of years show a multitude of benefits for both body and mind

By Matthieu Ricard, Antoine Lutz and Richard J. Davidson

Illustration by Marcos Chin

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WHEN THE SOCIETY FOR NEUROSCIENCE ASKED TENZIN GYATSO, the 14th Dalai Lama (the leader of Tibetan Buddhism), to address its annual meeting in Washington, D.C., in 2005, a few hundred members among the nearly 35,000 or so attending the meeting petitioned to have the invitation rescinded. A religious leader, they felt, had no place at a scientific meeting. But this particular leader turned out to have a provocative and ultimately productive question to pose to the gathering. "What relation," he asked, "could there be between Buddhism, an ancient Indian philosophical and spiritual tradition, and modern science?"

The Dalai Lama, putting action before rhetoric, had already started trying to find answers to his own question. Back in the 1980s, he had sparked a dialogue about science and Buddhism, which led to the creation of the Mind & Life Institute, dedicated to studying contemplative science. In 2000 he brought new focus to this endeavor: he launched the subdiscipline of "contemplative neuroscience" by inviting scientists to study the brain activity of expert Buddhist meditators—defined as having more than 10,000 hours of practice.

For nearly 15 years more than 100 monastics and lay practitioners of Buddhism and a large number of beginning meditators have participated in scientific experiments at the University of Wisconsin–Madison and at least 19 other universities. The article you are reading, in fact, is the product of a collaboration between two neuroscientists and a Buddhist monk who originally trained as a cell biologist.

A comparison of the brain scans of meditators with tens of thousands of hours of practice with those of neophytes and nonmeditators has started to explain why this set of techniques for training the mind holds great potential for supplying cognitive and emotional benefits. The goals of meditation, in fact, overlap with many of the objectives of clinical psychology, psychiatry, preventive medicine and education. As suggested by the growing compendium of research, meditation may be effective in treating depression and chronic pain and in cultivating a sense of overall well-being.

The discovery of meditation's benefits coincides with recent neuroscientific findings showing that the adult brain can still be deeply transformed through experience. These studies show that when we learn how to juggle or play a musical instrument, the brain undergoes changes through a process called neuroplasticity. A brain region that controls the movement of a violinist's fingers becomes progressively larger with mastery of the instrument. A similar process appears to happen when we meditate. Nothing changes in the surrounding environment, but the meditator regulates mental states to achieve a form of inner enrichment, an experience that affects brain functioning and its physical structure. The evidence amassed from this research has begun to show that meditation can rewire brain circuits to produce salutary effects not just on the mind and the brain but on the entire body.

WHAT IS MEDITATION?

MEDITATION HAS ROOTS in the contemplative practices of nearly every major religion. The prevalence of meditation in the media has given the word various meanings. We will refer to

IN BRIEF

Meditation is an ancient pursuit that, in some form, is a part of nearly every world religion. In recent years its practice, derived from various branches of Buddhism, has made its way into the secular world as a means of promoting calmness and general well-being.

Three common forms of meditation—focused attention, mindfulness and compassion—are now practiced everywhere, from hospitals to schools, and have increasingly become an object of scrutiny in scientific laboratories worldwide.

Physiological changes in the brain—an altered volume of tissue in some areas—occur through meditation. Practitioners also experience beneficial psychological effects: they react faster to stimuli and are less prone to various forms of stress.

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Varieties of Contemplative Experience

Advances in neuroimaging and other technologies have enabled scientists to gain insight into what happens in the brain during three major forms of Buddhist meditation—focused attention, mindfulness, and compassion and loving kindness. The diagram offers a glimpse into the cycle of events that occurs in the practice of focused-attention meditation—and the corresponding activation of specific brain areas.

Focused Attention

This practice typically directs the meditator to concentrate on the in-and-out cycle of breathing. Even for the expert, the mind wanders, and the object of focus must be restored. A brain-scanning study at Emory University has pinpointed distinct brain areas that become involved as attention shifts.

Mindfulness

Also called open-monitoring meditation, mindfulness entails observing sights, sounds and other sensations, including internal bodily sensations and thoughts, without being carried away by them. Expert meditators have diminished activity in anxiety-related areas, such as the insular cortex and the amygdala.

Compassion and Loving Kindness

In this practice, the meditator cultivates a feeling of benevolence directed toward other people, whether friend or enemy. Brain regions that fire up when putting oneself in the place of another—the temporoparietal junction, for instance—show an increase in activity.

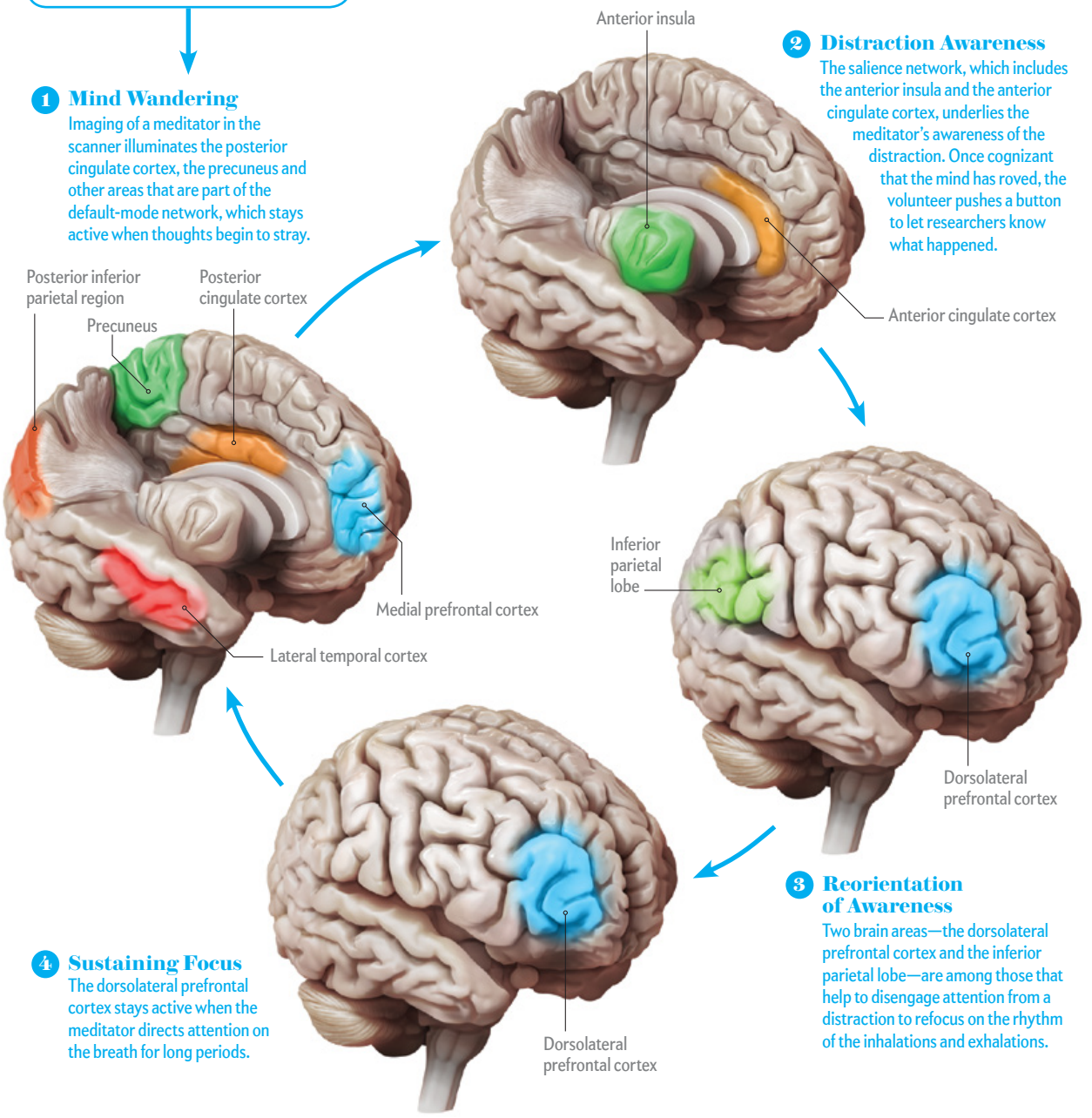
1 Mind Wandering
Imaging of a meditator in the scanner illuminates the posterior cingulate cortex, the precuneus and other areas that are part of the default-mode network, which stays active when thoughts begin to stray.
Posterior inferior parietal region
Precuneus
Posterior cingulate cortex
Medial prefrontal cortex
Lateral temporal cortex
2 Distraction Awareness
The salience network, which includes the anterior insula and the anterior cingulate cortex, underlies the meditator's awareness of the distraction. Once cognizant that the mind has roved, the volunteer pushes a button to let researchers know what happened.
Anterior insula
Anterior cingulate cortex
3 Reorientation of Awareness
Two brain areas—the dorsolateral prefrontal cortex and the inferior parietal lobe—are among those that help to disengage attention from a distraction to refocus on the rhythm of the inhalations and exhalations.
Inferior parietal lobe
Dorsolateral prefrontal cortex
4 Sustaining Focus
The dorsolateral prefrontal cortex stays active when the meditator directs attention on the breath for long periods.
Dorsolateral prefrontal cortex

Illustration by David C. Killpack

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meditation as the cultivation of basic human qualities, such as a more stable and clear mind, emotional balance, a sense of caring mindfulness, even love and compassion—qualities that remain latent as long as one does not make an effort to develop them. It is also a process of familiarization with a more serene and flexible way of being.

In principle, meditation is relatively simple and can be done anywhere. No equipment or workout attire is needed. The meditator begins by assuming a comfortable physical posture, neither too tense nor too lax, and by wishing for self-transformation and a desire for others' well-being and for the alleviation of their suffering. Later the practitioner must stabilize the mind, which is too often disorderly—and occupied by a stream of inner chatter. Mastering the mind requires freeing it from automatic mental conditioning and inner confusion.

We will examine here which regions of the brain light up during three common types of meditation developed through Buddhism and now practiced in secular programs in hospitals and schools throughout the world. The first one, focused-attention meditation, aims to tame and center the mind in the present moment while developing the capacity to remain vigilant to distractions. The second one, mindfulness, or open-monitoring meditation, tries to cultivate a less emotionally reactive awareness to emotions, thoughts and sensations occurring in the present moment to prevent them from spiraling out of control and creating mental distress. In mindfulness, the meditator remains attentive, moment by moment, to any experience without focusing on anything specific. Finally, another type of practice is known in Buddhist tradition as compassion and loving kindness and fosters an altruistic perspective toward others. A word of caution: Neuroimaging results discussed below should not be considered a one-to-one mapping between a given meditative state and specific brains networks. That is, functions in the brain are multidimensional, and any given meditative state engages a multitude of cognitive, affective and motivational features of the brain. Neuroimaging can visualize only one of these elements at a time.

UNDER THE SCANNER

NEUROSCIENTISTS HAVE NOW BEGUN to probe what happens inside the brain during the various types of meditation. Wendy Hasenkamp, then at Emory University, and her colleagues used brain imaging to identify correlated neural activity associated with focused-attention meditation. In the scanner, the participants trained their attention on the sensation produced by breathing. Typically during this form of meditation, the mind wanders from an object, and the meditator must recognize this and then restore attention to the gradual rhythm of the inhaling and exhaling. In this study, the meditator had to signal mind wandering by pressing a button. Researchers identified four phases of a cognitive cycle: an episode of mind wandering, a moment of becoming aware of the distraction, a phase of reorienting attention and a resumption of focused attention.

Each of the four phases involves particular brain networks. The first part of the cycle, when a distraction occurs, increases activity in the wide-ranging default-mode network (DMN). This network includes areas of the medial prefrontal cortex, the posterior cingulate cortex, the precuneus, the inferior parietal lobe and the lateral temporal cortex. The DMN is known to become activated during mind wandering and to play a general role in building and updating internal models of the world based on long-term memories about the self or others.

The second phase, becoming aware of a distraction, correlates with the activity of other brain areas such as the anterior insula and the anterior cingulate cortex, regions of what is called the salience network. This network is thought to play a key role in selecting which stimuli deserve attention. Here its activity may facilitate the shift of the mind away from distractors, for instance.

The third phase engages additional areas—among them the dorsolateral prefrontal cortex and the lateral inferior parietal lobe—which are involved in orienting attention. Finally, in the fourth and last phase, the dorsolateral prefrontal cortex, which is involved in monitoring attention, continues to retain a high level of activity, as the meditator's attention remains directed toward an object such as the breath.

In our laboratory at Wisconsin, we further observed different patterns of activity depending on a practitioner's level of experience. Veteran meditators with more than 10,000 hours of practice showed more activity in these attention-related brain regions compared with novices. Paradoxically, the most experienced meditators demonstrated less activation than the ones without as much experience. Advanced meditators appear to acquire a level of skill that enables them to achieve a focused state of mind with less effort. These effects resemble the skill of expert musicians and athletes capable of immersing themselves in the "flow" of their performances with a minimal sense of effortful control.

To study the impact of focused-attention meditation, we also studied its volunteers before and after a three-month retreat with intensive meditation exercises for at least eight hours a day. They received headphones that broadcast sounds at a given frequency, occasionally mixed with slightly higher-pitched sounds. They had to focus on the sounds played in one ear for 10 minutes and react to periodically interspersed high-pitched tones. After the retreat, we found that meditators, compared with a nonmeditating control group, showed less trial-to-trial variation in their reaction times on this highly repetitive task, which lent itself easily to distractions. The result suggested that the meditators had an enhanced capacity to remain vigilant. The brain's electrical responses to high-pitched tones remained more stable at the second session only for the meditators.

STREAM OF CONSCIOUSNESS

THE SECOND TYPE of well-studied meditation also involves another form of attention. Mindfulness, or open-monitoring meditation, requires the meditator to take note of every sight or sound and track internal bodily sensations and inner self-talk. The person stays aware of what is happening without becoming overly preoccupied with any single perception or thought, returning to this detached focus each time the mind strays. As awareness of what is happening in one's surroundings grows, normal daily irritants—an angry colleague at work, a worried child at home—become less disruptive, and a sense of psychological well-being develops.

With Heleen Slagter, then in our group at Wisconsin, we sought to learn about the influence of this form of training on mental functioning by measuring the participants' capacity to detect rapidly presented visual stimuli—a means to measure mindfulness meditation, which is also sometimes called non-

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INNER PATHWAYS of brain activity register on an electroencephalogram as co-author Matthieu Ricard meditates.

JEFF MILLER *University of Wisconsin-Madison*

reactive awareness. To perform this experiment, we used a task in which the participants had to detect two numbers presented on a screen rapidly, amid a succession of letters. If the second number appears about 300 milliseconds after the first one, subjects often do not see the second, a phenomenon known as attentional blink.

If the second number appears after a delay of 600 milliseconds, it can be detected without difficulty. The attentional blink reflects the limits of the brain's ability to process two stimuli presented to the observer at close intervals. When too much of the brain's attention is devoted to processing the first number, the second number cannot always be detected, although the observer usually can see it on some of the trials. We hypothesized that mindfulness training could reduce the propensity to "get stuck," or absorbed, by seeing the first number. Mindfulness practice cultivates a nonreactive form of sensory awareness, which should result in a reduced attentional blink. As we predicted, after three months of an intensive retreat, the meditators perceived both numbers more frequently than the controls did. This improved perception was also reflected in lessened activity of a particular brain wave in response to the first number. Monitoring the P3b brain wave, used to assess how attention is allocated, indicated that meditators were capable of optimizing attention so as to minimize the attentional blink.

Staying aware of an unpleasant sensation can reduce maladaptive emotional responses and help one to move beyond the disagreeable feeling and may be particularly useful in dealing with pain. In our Wisconsin lab, we have studied experienced practitioners while they performed an advanced form of mindfulness meditation called open presence. In open presence, sometimes called pure awareness, the mind is calm and relaxed, not focused on anything in particular yet vividly clear, free from excitation or dullness. The meditator observes and is open to experience without making any attempt to interpret, change, reject or ignore painful sensation. We found that the intensity of the pain was not reduced in meditators, but it bothered them less than it did members of a control group.

Compared with novices, expert meditators' brain activity diminished in anxiety-related regions—the insular cortex and the amygdala—in the period preceding the painful stimulus. The meditators' brain response in pain-related regions became accustomed to the stimulus more quickly than that of novices after repeated exposures to it. Other tests in our lab have shown that meditation training increases one's ability to better control and buffer basic physiological responses—inflammation or levels of a stress hormone—to a socially stressful task such as giving a public speech or doing mental arithmetic in front of a harsh jury.

Several studies have documented the benefits of mindfulness on symptoms of anxiety and depression and its ability to improve sleep patterns. By deliberately monitoring and observing their thoughts and emotions when they feel sad or worried, depressed patients can use meditation to manage negative thoughts and feelings as they arise spontaneously and so lessen rumination. In 2000 clinical psychologists John Teasdale, then at the University of Cambridge, and Zindel Segal of the University of Toronto showed that for patients who had previously suffered at least three episodes of depression, six months of mindfulness practice, along with cognitive therapy, reduced the risk of relapse by nearly 40 percent in the year following the onset of a severe depression. More recently, Segal demonstrated that the intervention is superior to a placebo and has a protective effect against relapse comparable to standard maintenance antidepressant therapy.

COMPASSION AND LOVING KINDNESS

THE THIRD FORM of meditation under study cultivates attitudes and feelings of loving kindness and compassion toward other people, whether they are close relatives, strangers or enemies. This practice entails being aware of someone else's needs and then experiencing a sincere, compassionate desire to help that person or to alleviate the suffering of other people by shielding them from their own destructive behavior.

To generate a compassionate state may sometimes entail the meditator feeling what another person is feeling. But having one's emotions resonate empathetically with the feelings of another person does not by itself suffice to yield a compassionate mindset. The meditation must also be driven by an unselfish desire to help someone who is suffering. This form of meditation on love and compassion has proved to be more than just a spiritual exercise. It has shown potential to benefit health care workers, teachers and others who run the risk of emotional

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burnout linked to the distress experienced from a deeply empathetic reaction to another person's plight.

The meditator begins by focusing on an unconditional feeling of benevolence and love for others, accompanied by silent repetition of a phrase conveying intent, such as "May all beings find happiness and the causes of happiness and be free from suffering and the causes of suffering." In 2008 we studied experienced volunteers who had practiced this form of training for thousands of hours and found an increase in activity in several brain regions while they listened to voices conveying distress. The secondary somatosensory and insular cortices, known to participate in empathetic and other emotional responses, were more activated for experts than controls in response to the distressed voice, suggesting an enhanced ability to share the feelings of others without reporting any sign of becoming emotionally overwhelmed. The practice of compassion meditation also produced more activity in areas such as the temporoparietal junction, the medial prefrontal cortex and the superior temporal sulcus, all typically activated when we put ourselves in the place of another.

More recently, Tania Singer and Olga Klimecki, both at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany, in collaboration with one of us (Ricard), sought to distinguish differences between the effects of empathy and compassion on meditators. They noted that compassion and altruistic love were associated with positive emotions, and they suggested that emotional exhaustion or burnout was, in fact, a kind of empathy "fatigue."

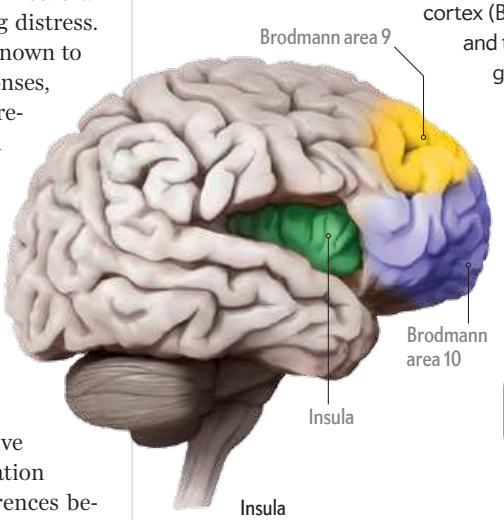
According to the Buddhist contemplative tradition from which this practice is derived, compassion, far from leading to distress and discouragement, reinforces an inner balance, strength of mind and a courageous determination to help those who suffer. If a child is hospitalized, the presence of a loving mother at his side holding his hand and comforting him with tender words will no doubt do that child more good than the anxiety of a mother overwhelmed with empathetic distress who, unable to bear the sight of her sick child, paces back and forth in the hallway. In the latter case, the mother may then end up with the common experience of burnout, which, in one U.S. study, beset about 60 percent of the 600 caregivers surveyed.

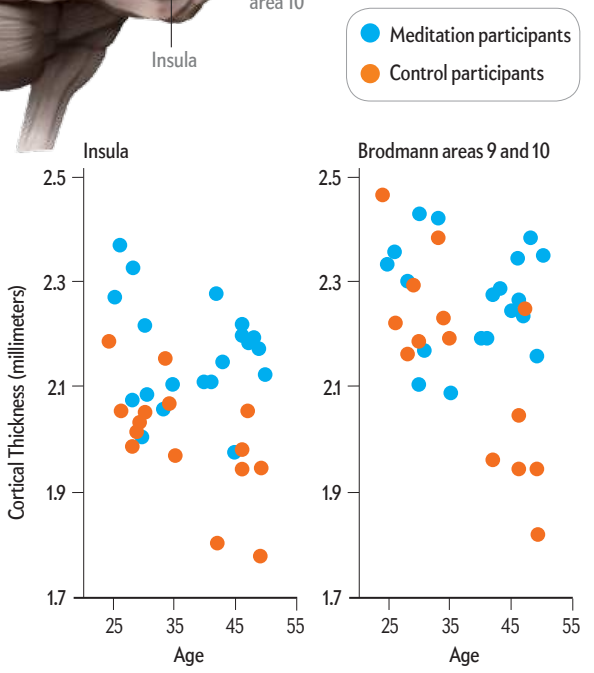
To further explore the mechanisms of empathy and compassion, Klimecki and Singer divided about 60 volunteers into two groups. One meditated on love and compassion, and the other experimental regimen trained participants to cultivate feelings of empathy for others. Preliminary results showed that after a week of meditation-based loving kindness and compassion, novice subjects watched video clips showing suffering people with more positive and benevolent feelings. The other subjects, who devoted a week to an experimental regimen that just cultivated empathy, experienced emotions that resonated deeply with others' sufferings. But these emotions also brought about negative feelings and thoughts, and this group experienced more distress, sometimes to the point of not being able to control their emotions.

Aware of these destabilizing effects, Singer and Klimecki added training for the empathy group in compassion and loving kindness meditation. They then observed that this additional exercise counterbalanced the detrimental effects of training in empathy alone: negative emotions diminished, and positive emotions increased. These results were accompanied by corresponding changes in the areas of several brain networks associated with compassion, positive emotions and maternal love, including the orbitofrontal cortex, the ventral striatum and the anterior cingulate cortex. The researchers, moreover, were able to demonstrate that a week of training in compassion increased prosocial behavior in a virtual game specially developed to measure the capacity to help others.

Grow More Brain

Researchers from several universities explored whether meditation might bring about structural changes in brain tissue. Using magnetic resonance imaging, they found that 20 experienced practitioners of one type of Buddhist meditation had a greater volume of brain tissue in the prefrontal cortex (Brodmann areas 9 and 10) and the insula than a control group did (*graphs*). These regions play a role in processing attention, sensory information and internal bodily sensations. Future long-term studies will be needed to confirm this finding.





SOURCE: "MEDITATION EXPERIENCE IS ASSOCIATED WITH INCREASED CORTICAL THICKNESS," BY SARA W. LAZAR ET AL., IN *NEUROREPORT*, VOL. 16, NO. 17; NOVEMBER 28, 2005

A DOOR TO CONSCIOUSNESS

MEDITATION EXPLORES the nature of the mind, providing a way to study consciousness and subjective mental states from

Illustration by David C. Killpack (brain)

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the first-person perspective of the meditator. In a collaboration with expert Buddhist meditators at Wisconsin, we have studied the brain's electrical activity using electroencephalography (EEG) during compassion meditation in which the meditators described the well-defined sense of self as becoming less fixed and permanent.

We found that these long-term Buddhist practitioners were able, at will, to sustain a particular EEG pattern. Specifically, it is called high-amplitude gamma-band oscillations and phase synchrony at between 25 and 42 hertz. The coordination of brain oscillations may play a potentially crucial role in the brain's building of temporary networks that can integrate cognitive and affective functions during learning and conscious perception, a process that can bring about lasting changes in brain circuitry.

High-amplitude oscillations persisted throughout the meditation for several dozens of seconds and gradually increased as practice progressed. These EEG traces differed from those of control subjects, in particular, in the lateral frontoparietal cortex. Changes in electrical activity may reflect an increased awareness in expert meditators of their surroundings and their internal mental processes, although additional research is needed to better understand the functioning of gamma oscillations.

Meditation brings about changes not just in well-defined cognitive and emotional processes but also in the volume of certain brain areas, possibly reflecting alterations in the number of connections among brain cells. A preliminary study by Sara W. Lazar of Harvard University and her colleagues showed that among longtime meditators, as compared with a control group, the volume of the brain's darker tissue, its gray matter, differed in the insula and prefrontal cortices—specifically, regions called Brodmann areas 9 and 10, which are frequently activated during various forms of meditation. These distinctions were most pronounced in older participants in the study, suggesting that meditation might influence the thinning of brain tissue that comes with aging.

In a follow-up study, Lazar and her colleagues also showed that mindfulness training decreased the volume of the amygdala, a region involved in fear processing, for those participants who showed the most noticeable reductions in stress over the course of training. Eileen Luders of the University of California, Los Angeles, and her colleagues further observed differences in meditators in the fibers called axons that connect different brain regions, suggesting an enhanced number of brain connections. This observation may support the hypothesis that meditation actually induces structural alterations in the brain. An important limitation of this research relates to the lack of long-term longitudinal studies that follow a group over the course of many years and to the absence of comparisons between meditators and people of similar backgrounds and ages who do not meditate.

Some evidence even exists that meditation—and its ability to enhance overall well-being—may diminish inflammation and other biological stresses that occur at the molecular level. A collaborative study between our group and one led by Perla Kaliman of the Institute of Biomedical Research of Barcelona showed that one day of intensive mindfulness practice in experienced meditators turned down the activity of inflammation-related genes and altered the functioning of enzymes involved with turning genes on and off. A study by Cliff Saron of the University of California, Davis, looked at the effect of meditation on a molecule involved with regulating the longevity of a cell. The molecule in question was an enzyme called telomerase that lengthens DNA segments at the ends of chromosomes. The segments, called telomeres, ensure stability of the genetic material during cell division. They shorten every time a cell divides, and when their length decreases below a critical threshold, the cell stops dividing and gradually enters a state of senescence. Compared with a control group, the meditators who showed the most pronounced reductions in psychological stress also had higher telomerase activity by the end of the retreat. This finding suggests that mindfulness training might slow processes of cellular aging among some practitioners.

A PATH TO WELL-BEING

ABOUT 15 YEARS OF RESEARCH have done more than show that meditation produces significant changes in both the function and structure of the brains of experienced practitioners. These studies are now starting to demonstrate that contemplative practices may have a substantive impact on biological processes critical for physical health.

More studies using well-defined, randomized controlled trials are needed to isolate meditation-related effects from other psychological factors that can influence the outcome of a study. Other variables that may affect study results are the level of motivation of a practitioner and the roles played by both teachers and students in a meditation group. Further work is needed to understand the possible negative side effects of meditation, the desirable length of a given practice session and the way to tailor it to a person's specific needs.

Even with the requisite cautions, research on meditation provides new insights into methods of mental training that have the potential to enhance human health and well-being. Equally important, the ability to cultivate compassion and other positive human qualities lays the foundation for an ethical framework unattached to any philosophy or religion, which could have a profoundly beneficial effect on all aspects of human societies. SA

Matthieu Ricard is a Buddhist monk who trained as a cellular biologist before he left France to become a student of Buddhism in the Himalayas about 40 years ago.

Antoine Lutz is a research scientist at the French National Institute of Health and Medical Research and also works at the University of Wisconsin–Madison. He has been a leader in studying the neurobiology of meditation.

Richard J. Davidson has pioneered the science of meditation as director of the Waisman Laboratory for Brain Imaging and Behavior and the Center for Investigating Healthy Minds at the University of Wisconsin–Madison.

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HEALTHY BODY, HEALTHY MIND

IN SEARCH OF THE OPTIMAL BRAIN DIET

The field of nutritional psychiatry is taking off as scientists home in on the ingredients for good mental health and cognitive staying power

By Bret Stetka

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CAROLYN FEELS GREAT THESE DAYS. SHE EXERCISES. SHE'S SOCIALLY active. She spends as much time with her four grandchildren as possible. But it wasn't always that way. A retired radiology film librarian from Pittsburgh, she began feeling apathetic and isolated seven years ago. "I'd just lost my mother, and my two sons had moved away," recalls Carolyn, now 75. She also struggled with excess weight, diabetes and chronic lung disease. She was grieving, eating a worrisome amount of junk food and slipping into what looked a lot like depression.

A few years later a friend told Carolyn about a depression-prevention study at the University of Pittsburgh. She signed up immediately. All 247 participants were, like her, older adults with mild depressive symptoms—people who without treatment face a 20 to 25 percent chance of succumbing to major depression. Half received about five hours of problem-solving therapy, a cognitive-behavioral approach designed to help patients cope with stressful life experiences. The rest, including Carolyn, received dietary counseling. Guided by a social worker, she discovered that she liked salmon, tuna and a number of other "brain-healthy" foods—which quickly replaced all the chips, cake and candy she was eating.

When the trial concluded in 2014, the results came as a surprise—to the researchers at least. The dietary counseling was not meant to have any substantial effect; Carolyn's group was the experiment's control. And yet psychiatrist Charles Reynolds and his colleagues discovered that both interventions had significantly reduced the risk of depression—by approximately the same amount. When they reviewed the data, all the patients scored on average 40 to 50 percent lower on the Beck Depression Inventory test, a common measure of depressive symptoms, 15 months after their sessions ended. What is more, only about 8 percent, regardless of the therapy they received, had fallen into major depression.

It cannot be ruled out that a placebo effect contributed to the improvements seen in both groups. Meeting with a health care professional and being proactive about getting better in and of itself may have helped participants feel more upbeat. In Carolyn's view, however, she had reversed her downward spiral largely by changing how she ate.

She is not alone in making that connection. Among scientists and clinicians there is a growing appreciation of the critical interplay between diet and brain health. The evidence is preliminary, and it is hard to tease out cause and effect. Perhaps people who eat well are also apt to have other healthy brain habits, such as regular exercise and good sleep routines. Or maybe depressed people tend to self-medicate with Oreos. But the data continue to accumulate. Every year the list of correlations between certain foods and mental well-being grows: fish and other sources of omega-3 fatty acids might help fend off

IN BRIEF

Research indicates that traditional diets from the Mediterranean, Scandinavia and Japan help to preserve our psychological and cognitive well-being.

These diets all feature fish, one of the best sources of omega-3 fatty acids—nutrients that play a vital role in promoting neuronal health and that may have helped drive the evolution of the human brain.

Studies indicate that diet changes may alleviate a range of psychiatric symptoms, and mental health practitioners may start to complement therapy and pharmaceutical treatments with recommended eating plans in the near future.

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Traditional Diets for Healthy Brains

Mediterranean

Research consistently finds the dietary patterns of cultures hugging the Mediterranean Sea to be among the healthiest in the world. Ingredients common to Greek, Italian, Spanish and Middle Eastern cuisine (*below*) are linked with improved cardiovascular, mental and neurological function.

Olive oil
Omega-3-rich fish (sardines, tuna, salmon)
Antioxidant-rich fruits and vegetables (tomatoes, peppers, eggplant)
Whole grains
Legumes
Moderate amounts of lean meat and red wine
Limited sugar and processed food

Okinawan

According to the World Health Organization, the Japanese have the highest life expectancy in the world—in part thanks to the population of Okinawa. Staples of the island group's traditional diet (*below*) include the nutrient-rich purple sweet potato, often eaten in place of rice. Indeed, Okinawans tend to eat less fish, meat, rice and sugar—and fewer calories overall—than do those in other parts of the country.

Antioxidant-rich vegetables (Okinawan purple sweet potatoes)
Seaweed
Some fish
Some meat
Limited sugar and white rice intake

Scandinavian

Swedish meatballs aside, Scandinavians cook, collect and cultivate a host of foods that together constitute the new Nordic diet, one of the world's healthiest. It is associated with reduced inflammation and decreased risk for cardiovascular disease and diabetes, both of which can influence brain health. Of particular note, Scandinavians tend to cook with canola oil, also called rapeseed oil, which contains far more omega-3 fatty acids than olive oil.

Fruits (lingonberries)
Vegetables (potatoes)
Nuts/whole grains (rye breads very common)
Seafood
Moderate amounts of meat and dairy
Canola (rapeseed) oil

psychosis and depression; fermented foods such as yogurt, pickles and sauerkraut seem to ease anxiety; green tea and antioxidant-rich fruits may help keep dementia at bay. And so on.

There is probably no single ingredient, no happy seed from the jungles of beyond, that is sure to secure a better mood or mental acuity into old age. But there do appear to be specific dietary patterns—calibrated by millions of years of human evolution—that boost our cognitive and psychological fitness. Within the nascent field of nutritional psychiatry, consensus is building about just what types of diets are best. And perhaps most exciting is the prospect that dietary intervention could serve as a valuable adjunct to medication and other therapies for mental disorders—just as it does in so many other areas of medicine.

GOOD DIET, BAD DIET

WHEN IT COMES TO PROMOTING brain health, the diet supported by the strongest data draws on traditional eating patterns from Italy, Greece and Spain. The so-called Mediterranean diet consists primarily of fruits, vegetables, nuts, whole grains, fish, lean meats in moderation, olive oil and maybe a little red wine. In 2017 the first ever randomized controlled clinical trial to test a prescribed diet to treat depression was published in *BMC Medicine*. The "SMILES" trial reported that after 12 weeks of consuming a Mediterranean-like diet, patients suffering from moderate to severe depression experienced significantly greater improvements on a commonly used depression symptom measure called the Montgomery-Åsberg Depression Rating scale (MADRS), compared with the control group. In 2011 public health expert Almudena Sánchez-

ALAMY

EVIDENCE LINKS STEREOTYPICAL Western diets, which are heavy in processed and fatty foods, to higher rates of depression and anxiety. Unhealthy diets most likely contribute to a range of neuropsychiatric disorders by increasing inflammation.

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COLD-WATER FISH, such as salmon, tuna and sardines (*shown here*), are rich sources of DHA, a fatty acid that contributes to the growth, structure and function of nerve cells.

Villegas of the University of Las Palmas de Gran Canaria and her colleagues assessed the relation between this diet and depression in more than 12,000 healthy Spaniards over the course of a median of six years each. They found that compared with people who did not eat a Mediterranean diet, those who did were significantly less likely to succumb to depression. For the subjects who followed the diet most closely, the risk dropped by a substantial 30 percent.

Sánchez-Villegas later confirmed the association in another large trial. The PREDIMED (Prevention with Mediterranean Diet) study—a multicenter research project evaluating nearly 7,500 men and women across Spain—initially looked at whether a Mediterranean diet, supplemented with extra nuts, protects against cardiovascular disease. It does. In 2013 Sánchez-Villegas and other investigators also analyzed depression data among PREDIMED's participants. Again, compared with subjects who ate a generic low-fat diet, those who adhered to the nut-enriched Mediterranean diet had a lower risk for depression. This was especially true among people with diabetes, who saw a 40 percent drop in risk. Perhaps these patients, who cannot adequately process glucose, benefited the most because the Mediterranean diet minimized their sugar intake.

Indeed, a central feature of the diet is that it is low in sugar, as well as processed foods and fatty meats, which are commonplace on most Western menus. Nutritional psychiatry researcher and SMILES trial lead author Felice N. Jacka of Deakin University and the University of Melbourne in Australia was one of the first to demonstrate an association between stereotypical Western diets and depression and anxiety. Most recently, she has drawn another link between poor diet and, quite literally, a shrinking brain. In September 2015 she and her colleagues discovered that older adults who consumed a Western diet for four years not only suffered higher rates of mood disorders but also had a significantly smaller left hippocampus on MRI scans. The hippocampus, composed of two seahorse-shaped arcs of brain tissue deep underneath our temples, is critical to memory formation. Jacka focused on the hippocampus because animal studies have also noted diet-related changes there.

Scientists have proposed a number of possible mechanisms to explain this damage. Jacka's findings parallel other research revealing that high-sugar diets can prompt runaway inflammation and trigger a cascade of other metabolic changes that ultimately impair brain function. Ordinarily inflammation is part of our immune system's arsenal to fight infection and encourage healing, but when it is misdirected or overly aggressive, it can destroy healthy tissues as well. According to numerous studies, inflammation plays a role in a range of brain disorders—from depression and bipolar disorder to possibly autism, schizophrenia and Alzheimer's disease.

Two meta-analyses from 2010 and 2012 collectively reviewed data from 53 studies and reported significantly elevated levels of several blood markers of inflammation in depressed patients. And numerous studies have reported increased or altered activity of immune cells called microglia—which play a key role in the brain's inflammatory response—in patients with psychiatric disorders, including depression and schizophrenia. It is not clear whether inflammation causes mental illness in some cases, or vice versa. But the evidence suggests that many if not most known risk factors for psychiatric disorders, especially depression, promote inflammation; these include abuse, stress, grief and certain genetic predilections.

Jacka's work repeatedly points to traditional diets such as

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By Land or by Sea?

Experts debate how human ancestors found enough fatty acids to build better brains

Omega fatty acids, including docosahexaenoic acid, or DHA, are key to brain health and most likely helped to drive the evolution of the modern human brain. But how did early humans access these vital nutrients? The answer is a matter of some debate.

For nearly two decades archaeologist Curtis W. Marean, associate director of Arizona State University's Institute of Human Origins, has overseen excavations at a site called Pinnacle Point on South Africa's southern coast, near where a newly discovered early human species, *Homo naledi,* was recently unearthed. His work there suggests that sometime between 195,000 and 123,000 years ago, during a glacial period known as Marine Isotope Stage 6 (MIS6), humans made a significant shift in their eating habits, moving from foraging for terrestrial plants, animals and the occasional inland fish to relying on the rich, predictable shellfish beds in the area.

Marean believes that this change occurred when early humans learned to exploit the bimonthly spring tides. And to do so, he says, our brains were already fairly well evolved. "Accessing the marine food chain could have had huge impacts on fertility, survival and overall health, including brain health," Marean explains, in part because of the high return on omega-3 fatty acids. But before MIS6, he speculates, hominins would have had access to plenty of brain-healthy terrestrial nutrition, including by feeding on animals that consumed omega-3-rich plants and grains.

Others disagree, at least in part. "I'm afraid the idea that ample DHA was available from the fats of animals on the savanna is just not true," says psychiatrist Michael A. Crawford of Imperial College London. "The animal brain evolved 600 million years ago in the ocean and was dependent on DHA and compounds essential to the brain such as iodine, which is also in short supply on land. To build a brain, you would need building blocks that were rich at sea and on rocky shores."

Crawford's early biochemical work focused on showing that DHA is not readily accessible from the muscle tissue of land animals. Using DHA tagged with a radioactive isotope, he and his colleagues also demonstrated that "ready-made" DHA—such as that found in shellfish—is incorporated into the developing rat brain with 10-fold greater efficiency than plant-sourced DHA.

Crawford's colleague and collaborator, physiologist Stephen Cunnane of the University of Sherbrooke in Quebec, also feels that aquatically sourced food was crucial to human evolution. But he believes that before MIS6, inland hominins had already incorporated fish from lakes and rivers into their diet for millions of years.

EVEN BEFORE EARLY humans began foraging for seafood, they may have incorporated nutrient-rich fish from lakes and rivers into their diets, helping them to build healthy brains.

He suggests that it was not just omega-3s but a cluster of nutrients found in fish (including iodine, iron, zinc, copper and selenium) that contributed to our big brain. "I think DHA was hugely important to our evolution and brain health, but I don't think it was a magic bullet all by itself," Crawford says.

All three researchers are confident that higher intelligence evolved gradually over millions of years as mutations inched the cognitive needle forward, conferring survival and reproductive advantages. But advantages such as, say, figuring out how to shuck oysters—as well as track the spring tides—threw open the Darwinian floodgates. Cunnane comments: "Once we were able to access the coastal food chain in Africa—far more rich and reliable than inland sources of fish—brain and cultural evolution exploded." —*B.S.*

Mediterranean, Japanese and Scandinavian ones—all of which tend to be noninflammatory—as being best for our neurological and mental health. "There is no doubt that stress and uncomfortable emotions can cause us to reach for the biscuit tin—they don't call them comfort foods for nothing!" she admits. "But consistently the data show that the main constituents of a healthy brain diet include fruits, vegetables, legumes, nuts, fish, lean meats and healthy fats such as olive oil."

BRAIN-BUILDING FATTY ACIDS

INCREASINGLY, researchers are finding that the power of these more traditional diets extends beyond just supplanting bad food with good. In the summer of 2015 neuroscientists Amandine Pelletier, Christine Barul, Catherine Féart and their colleagues, all then at the University of Bordeaux in France, discovered that a Mediterranean diet may actually help physically preserve neuronal connections in the brain. They used a highly

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sensitive neuroimaging analysis technique called voxel-based morphometry to identify subtle changes in brain anatomy over time. And in September 2015 nutritional epidemiologist Martha C. Morris of Rush University and her co-workers reported that the MIND diet—a hybrid of the Mediterranean and the high-nutrient, low-salt DASH diet—may help slow cognitive decline and possibly even help prevent Alzheimer's. When they tested cognitive ability in 960 older adults, those who had followed the MIND diet for roughly five years achieved scores matching those of people 7.5 years younger.

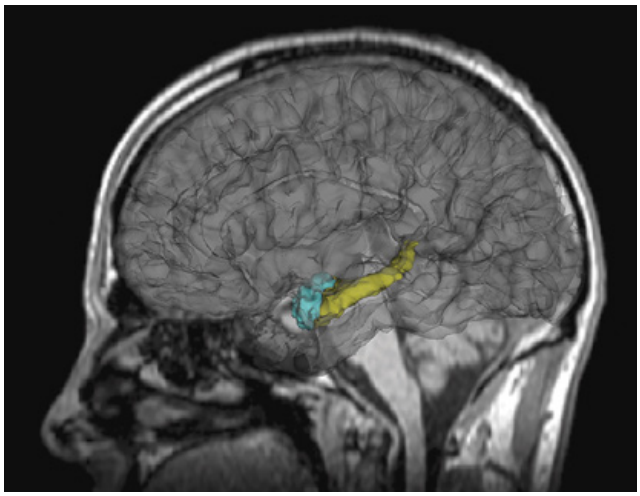
Our evolutionary backstory could explain these neuroprotective effects. Sometime between 195,000 and 125,000 years ago, humans may have nearly gone extinct. A glacial period had set in that probably left much of the earth icy and barren for 70,000 years. The population of our hominin ancestors plummeted to possibly only a few hundred in number, and most experts agree that everyone alive today is descended from this group. Exactly how they—or early modern humans, for that matter—managed to stay alive during recurring glacial periods is less clear. But as terrestrial resources dried up, foraging for marine life in reliable shellfish beds surrounding Africa most likely became essential for survival. Graduate student Jan De Vynck of Nelson Mandela Metropolitan University in South Africa has shown that one person working those shellfish beds can harvest a staggering 4,500 calories an hour.

The archaeological record corroborates the idea and indicates that our ancestors depended on a diet heavy in shellfish and cold-water fish—both rich sources of omega-3 fatty acids. These fats may have driven the evolution of our uniquely complex brains, which are 60 percent fat in composition. One omega-3 in particular, docosahexaenoic acid, or DHA, is arguably the single nutrient most strongly associated with brain health.

In 1972 psychiatrist Michael A. Crawford, now at Imperial College London, co-published a paper concluding that the brain is dependent on DHA and that DHA sourced from the sea was critical to mammalian brain evolution, especially human brain evolution. For more than 40 years he has argued that the rising rates of brain disorders are a result of post–World War II dietary changes—especially a move toward land-sourced food and, subsequently, the embrace of low-fat diets. He feels that omega-3s from seafood were critical to the human species' rapid neural march toward higher cognition [*see box on preceding page*].

Many studies have confirmed DHA's importance to the development, structure and function of the human brain: it is a component of neuronal cell membranes, facilitates neuron-to-neuron communication, and is also thought to boost levels of brain-derived neurotrophic factor, a protein that supports the growth and survival of brain cells. Given the starring role this and other omega-3 fatty acids play in shaping and maintaining our most complex organ, it makes intuitive sense that incorporating more of them into our diet—by emphasizing seafood—might, as the nutritional data suggest, protect the brain from going haywire. Also of note, DHA appears to decrease chronic brain-harming inflammation.

Fatty acids aside, there is another important link between our ancestors' diets, inflammation and mental health. As we evolved, the trillions of bacteria, fungi and other microorganisms that colonize our bodies and constitute the majority of our cells came along for the ride. This so-called microbiota—and its collective genes, the microbiome—makes a critical contribution to the formation and function of our digestion and immune system. A growing number of findings now suggest that disrupting it through poor eating habits comes at a cost to the brain.



IN BOTH ANIMAL AND HUMAN studies, typical unhealthy Western diets appear to cause damage to the hippocampus (*yellow on MRI scan*), a brain structure that plays an essential role in learning and memory. In one recent study, older adults who had consumed poor-quality diets over the course of four years had a smaller left hippocampus compared with peers who ate more healthfully.

COURTESY OF NICOLAS CHERBUIN

A BLOW TO THE GUT

IN ONE STRIKING (if slightly nauseating) experiment in 2014, then 23-year-old student Tom Spector wiped out about a third of the bacterial species in his gut by limiting his diet to McDonald's fast food. It took only 10 days. Spector played the guinea pig for two reasons: as a project to complete his genetics degree and to provide data for his father, Tim, a genetic epidemiology professor at King's College London, who studies how processed diets affect gastrointestinal bacteria. The Spector family's research did not assess specific health consequences—they were measuring only the drop in floral diversity in Tom's gut—but Tom did report feeling lethargic and down after days of burgers, fries and sugary soda. The decline in species was so drastic that Tim sent the results to three laboratories for confirmation.

Diet-induced shifts in the microbiota of the kind Spector brought on himself can rapidly ratchet up inflammation in the gut. On top of the ill effects just described, gastrointestinal inflammation can deplete our supply of serotonin, a neurotransmitter long tied to depression and other psychiatric disorders. About 90 percent of our serotonin is produced in the gut when certain microbes interact with cells lining the gastrointestinal tract (some microbes even produce a portion of our serotonin themselves). But by-products of inflammation convert serotonin's metabolic precursor, tryptophan, to a compound that generates neurotoxic metabolites linked with depression, schizophrenia and Alzheimer's.

The good news is that dietary changes can not only wreck our microbial diversity, they can boost it, reducing gastrointestinal

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inflammation in the process. In 2015 a group at the University of Pittsburgh conducted a study in which 20 African-Americans from Pennsylvania swapped diets with 20 rural black South Africans. In place of their usual low-animal-fat, high-fiber diet, the Africans consumed burgers, fries, hash browns, and the like. The Americans eschewed their normal fatty foods and refined carbohydrates for beans, vegetables and fish. After just two weeks the Americans' colons were less inflamed, and their fecal samples showed a 250 percent spike in butyrate-producing bacterial species. Butyrate is thought to reduce the risk of cancer. The South Africans, on the other hand, underwent microbial changes associated with increased cancer risk.

"Dietary changes are the easiest way to alter your microbiome and help to control inflammation," says psychiatrist Emily Deans of Harvard Medical School. She believes diet is every bit as important as pills and psychotherapy in managing mental illness—a view informed by her own clinical practice. "I discuss nutrition with just about all of my patients," she adds, "and I think it can really help in managing conditions like depression, at least in some people." Deans also feels that timing of meals can influence mood, and research suggests that eating on a regular schedule can improve mental health.

Deans acknowledges that science has a long way to go before we fully understand the brain-diet relation. She is also wary of the massive probiotic industry that has, like the supplement industry in general, barreled ahead of the minimal but growing scientific evidence suggesting that probiotics might be effective in preventing or treating mental illness. "You can do studies with, for example, certain vitamins, and some might turn out positive and others negative," she explains. "But the truth is vitamins exist in all sorts of different chemical states in food and in just one state in supplements." This difference in form between nutrients in food versus pills explains why the data tend to favor nutrition through diet rather than supplementation. "I think we can safely say that certain dietary patterns seem to promote a healthy microbiome," Deans speculates, "like the Mediterranean diet and diets that include lots of fiber, fermented foods and fish." And a healthy microbiome may be essential for a healthy brain.

FOOD FOR THOUGHT

FOR SEVEN YEARS NOW Carolyn has been eating better—focusing on seafood and cutting back on sugar. She has lost weight, and her diabetes is under control. "It's part of a whole new way of life," she says, "knowing that what I eat can affect how I feel." That awareness is building momentum among patients and practitioners alike. In March 2015 a large team of clinicians and researchers published a report in the *Lancet Psychiatry* on behalf of the International Society for Nutritional Psychiatry Research—an organization Jacka co-founded in 2013. Citing modest therapeutic gains yielded by many psychiatric drugs, the authors called for the integration of nutrition-based approaches into mental health care. "The emerging and compelling evidence for nutrition as a crucial factor in the high prevalence and incidence of mental disorders," they wrote, "suggests that diet is as important to psychiatry as it is to cardiology, endocrinology, and gastroenterology."

Thanks to our evolutionary lineage (and plenty of fish), attention to our diets may prove critical to reversing the rising rates of mental illness around the world, lowering the proportion of people struggling with various forms of dementia, and staving off milder psychiatric symptoms and disorders. There is little doubt that eating right can help shuttle us through tough times—just as it may have done 160,000 years ago for a small group of humans huddled in coastal African caves.

DIET MAY BE "AS IMPORTANT TO PSYCHIATRY AS IT IS TO CARDIOLOGY, ENDOCRINOLOGY, AND GASTROENTEROLOGY," SAYS A 2015 REPORT IN THE *LANCET PSYCHIATRY*.

One of the leading proponents of leveraging diet to better brain health, Jacka is encouraged that interventional studies—in which patients are actually "prescribed" a particular diet and tracked over time, as they were in her own SMILES study—are finally getting under way. Such research will be able to offer more definitive proof of the connection between diet and mental and cognitive well-being.

More and more doctors and patients are beginning to see dietary interventions as a beacon of hope after several decades of disappointing psychiatric drug development. Too many patients suffering from mental illness or dementia do not respond adequately to existing medications, if at all. For example, selective serotonin reuptake inhibitors such as Prozac—one of the most commonly prescribed drug classes for treating depression—appear effective only in severe cases; they are often no better than placebo for mild to moderate disease. As scientists learn more about the pathologies behind mental and cognitive disorders, new and promising therapeutic targets will surely emerge. But it is clear that nutrition-based treatment plans—free from side effects and low in cost—will also figure prominently in the future of dementia and psychiatric care. SA

Bret Stetka is an editorial director at Medscape (a subsidiary of WebMD) and a frequent contributor to *Scientific American.* His writing has appeared in *Wired* and online for the *Atlantic* and NPR.

MORE TO EXPLORE

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HEALTHY BODY, HEALTHY MIND

A RARE SUCCESS AGAINST ALZHEIMER'S

A gold-standard clinical trial provides evidence that diet, exercise and an active social life can help prevent cognitive decline

By Miia Kivipelto and Krister Håkansson

IN BRIEF

More than 200 experimental drugs intended to treat Alzheimer's disease have failed in the past 30 years. Without new therapies, the number of patients worldwide will increase dramatically by 2050.

A ray of hope has come recently from a clinical trial that showed that dementia's cognitive impairment might be prevented by paying close attention to various health factors.

Participants in the study who followed a regimen of health-related steps registered improvements on cognitive measures such as memory and mental-processing speed.

Results of this research suffice for health care professionals to begin making a series of recommendations to patients on diet, exercise and levels of social engagement that may help prevent dementia.

Illustration by Jon Foster

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MORE PEOPLE ARE REACHING A RIPE OLD AGE THAN EVER BEFORE. Life expectancy has increased from 45 years in the early 1800s to more than 80 today in most European countries and in Japan, Canada and Australia, among other nations. In fact, if the trend continues, a majority of babies born in these countries today will live past their 100th birthday. This greater longevity comes with some bad news. Although we manage to survive longer than preceding generations did, we often gain time without being healthier in those extra years. Studies from different parts of the world indicate that after age 60, most people have at least one chronic disorder, such as heart disease or diabetes, and a recent population-based study in Sweden found that at 80, only around one out of 10 individuals was free of chronic diseases. In fact, most people older than 80 in this population had two or more chronic illnesses.

Modern medicine has become increasingly adept at treating and controlling many of these conditions, but a few common age-related diseases have defied attempts to find preventive therapies or cures—most notably, Alzheimer's disease, the leading cause of dementia. Alzheimer's follows a merciless course that progressively deprives a person of memories and a sense of self-identity, losses that have devastating consequences for relatives and friends as well.

In the U.S., around 32 percent of people older than 85 have received an Alzheimer's diagnosis, often combined with other types of dementia, such as that caused by vascular disease. Estimates put the number worldwide with any kind of dementia at about 50 million. By 2050 if no new treatments succeed in delaying the condition, more than 130 million may suffer with some form of the disease. About 60 to 70 percent of these patients will have Alzheimer's dementia, and around 20 to 25 percent will be classified as suffering from the vascular form of the illness.

In spite of more than 100 ongoing clinical trials, no cure or drug has been able to halt the course of Alzheimer's. More than 200 experimental drugs intended to treat it have failed during the past 30 years. But all is not grim. New findings from a gold-standard clinical trial the two of us have been involved in indicate that cognitive impairment can be prevented or delayed even in the absence of new drugs by promoting changes in behavior and by managing vascular risk factors.

The study we conducted took its inspiration from epidemiological research that sought ways to reduce the risk of Alzheimer's. Such investigations, called association studies, measure, at different points, health-related variables, such as depression, high blood pressure, diet and exercise. Then, usually many years later, they investigate whether individuals go on to acquire a particular disorder. A strong correlation between a variable and the disease in question suggests that some aspect of our health history might merit being labeled as a risk factor. Also, if one of the observed variables correlates with a low risk of disease, the finding can be taken as a sign that it might be protective.

HOW WE LIVE

DURING THE PAST 10 TO 15 YEARS association studies have indicated that maintaining cardiovascular health and adopting certain measures—good diet, exercise, an active social life and the achievement of higher educational levels—may diminish the risk of both Alzheimer's and other dementias later in life, even for those who carry genes that place them at increased risk. Epidemiologists have also increasingly begun to discover specific factors that may be protective—for instance, living with a partner or consuming a Mediterranean diet (mainly based on fish, vegetables, fruit and olive oil). Some studies suggest that controlling, for example, blood pressure and diabetes may constitute primary prevention—protections against the onset of a disease. They might also afford secondary prevention, slowing memory loss and other symptoms in the earliest stages of illness.

Although association studies can flag a purported protective factor, they unfortunately cannot prove that taking these steps will actually prevent dementia. People who eat a Mediterranean diet or exercise three times a week may avoid disease because of some other variable ignored by epidemiological sleuths.

Epidemiologists try to deal with this problem by making statistical adjustments, but it is virtually impossible to discount every aspect of a person's life that could confound a study's conclusions. They can never be sure that they have succeeded, and sometimes the relevant data may not even exist. Obtaining reliable data on early childhood experiences is extremely difficult, although what happens during the first years might influence development of high blood pressure or some other aspect of health that contributes to the development of Alzheimer's late in life. Lacking all the necessary data can produce spurious associations among variables that lead to the wrong conclusions. Statistical equations, moreover, all but collapse under their own weight if too many variables are considered at the same time.

In 2010 the problem of establishing causality from association studies prompted a U.S. National Institutes of Health conference to conclude that not enough evidence existed to make firm rec-

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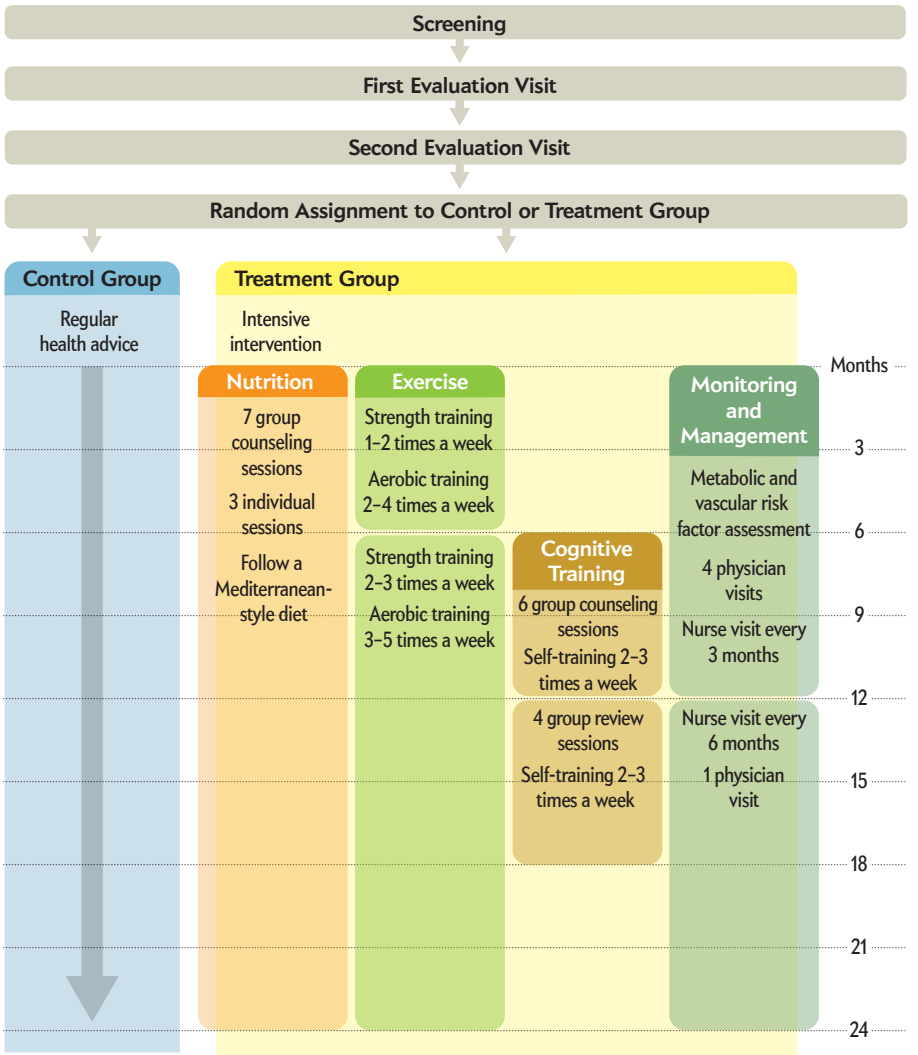
FINGERing Dementia

Between 2009 and 2011 a clinical trial—the Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER)—enrolled 1,260 men and women between the ages of 60 and 77. Of that number, 629 were randomly assigned to a control group, and 631 were directed to a treatment group. All of those recruited in both groups had a slightly higher risk for dementia. Members of the treatment group were then directed to follow a regimen of diet, exercise and cognitive training. They received nurse visits, initially every three months, and visited physicians five times during the two-year course of the trial to check on how well they were able to follow recommendations. Control group participants, in contrast, received only basic health advice during two physician visits.



ommendations on whether a given factor might diminish the risk of cognitive decline. To overcome this difficulty, a systematic review article from the NIH conference suggested that Alzheimer's researchers launch randomized controlled trials—and that any study undertaken examine not one but multiple factors that might prove to be pivotal in preventing dementia.

The randomized controlled trial is the gold standard that science uses to determine whether a treatment is in fact effective—in this case, whether a true cause-and-effect relation links variables (perhaps diet and exercise)—with outcomes such as avoiding cognitive decline. Participants in these trials are randomly assigned to either a treatment or a control group. To avoid biasing results, neither the researchers nor the study participants know which individuals are assigned to a particular group.

In the past investigators have undertaken relatively few long-term randomized controlled trials of whether lifestyle changes can improve health because accurately monitoring day-to-day behavior is challenging. But the NIH conference experts still recommended them as the best way to proceed because of the need for substantive data and because past randomized controlled trials looking at only a single variable have failed or produced mixed results. Moreover, Alzheimer's researchers have come to recognize the need to learn from successes in advancing prevention strategies for heart disease and diabetes, which relied on studies that looked at multiple risk factors.

THE STUDY

SINCE 2010 SEVERAL LONG-TERM, randomized controlled studies have progressed, and findings are now being reported. Our project—the Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER)—was the first to publish. FINGER's goal was to assess the effect on cognitive health of improved diet, physical exercise and mental training while providing regular health advice and cardiovascular health monitoring.

We and our colleagues wanted to know whether, over a two-year period, overall cognitive performance would differ between the treatment group—631 men and women between the ages of 60 and 77—and the 629 members of the control group. (The control subjects received health advice, and their cardiovascular

Graphics by Jen Christiansen

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health was checked regularly. If health problems were identified, such as high blood pressure, control group members were referred to a physician.) To optimize chances that the trial would succeed, we structured the pool of subjects to consist of individuals who had an elevated risk for cognitive decline, as judged by scores on a survey that measures dementia risk (the Cardiovascular Risk Factors, Aging and Dementia risk score).

In comparison with the control group, the intervention group received a mix of nutritional guidance, cognitive training and physical exercise, and the subjects' cardiovascular status was also more intensely monitored. The nutritional guidance aimed at a healthy balance of protein, fat, carbohydrates, dietary fibers and salt and included restrictions on consumption of trans-fatty acids, refined sugar and alcohol, all in accordance with recommendations by Finland's National Nutrition Council. The main ingredients in the recommended diet were fruits, vegetables, whole grains and rapeseed oil, along with a fish meal at least twice a week. The only food supplement was vitamin D.

Physical exercise included muscle-strength training, aerobic exercise and postural balance. The exercise program was individually tailored to each participant and led by a physiotherapist during the first six months, then performed independently by the participants in group sessions. The initial recommendation was to go to the gym one to two times a week for sessions of 30 to 45 minutes to train muscle strength. After six months of gradual increases in intensity, the participants reached a maximum level of two to three gym sessions of 60 minutes a week, which they then maintained during the remaining 18 months. In addition, subjects received advice to perform aerobic training twice a week and increase their regimen gradually to three to five times a week. Based on individual preferences, they could choose to engage in Nordic walking, aqua gym, jogging or calisthenics as part of the aerobic component of the intervention.

The intervention group also used a computer program to train on different cognitive tasks to enhance executive function (planning and organizing), memory improvement and mental speed. After six introductory group lessons led by a psychologist, group members trained on their own two to three times a week in 10- to 15-minute sessions during two six-month periods. Four group reviews monitored progress along the way and discussed topics such as age-related cognitive changes.

The participants also had regular checkups of metabolic and vascular health. They met with a study nurse on six occasions to measure weight, blood pressure, and hip and waist circumference. Physicians also reviewed these and other laboratory results with subjects five times during the two-year trial period, using them as a basis to encourage changes in daily habits.

By any standard, FINGER proved to be an intensive intervention for most participants, a drastic change to their lives during the two years it lasted. That most of them adhered to the routine was regarded as a success in itself. Only 12 percent dropped out, usually citing health problems. Further, just 46 of the 631 participants in the intervention group experienced any difficulty completing the tasks—the most common adverse event was muscle pain following physical training. We concluded that a comprehensive program of changes to one's daily activities in later life is practical to implement. But the more important question was whether the goal of preserving cognition had actually been reached.

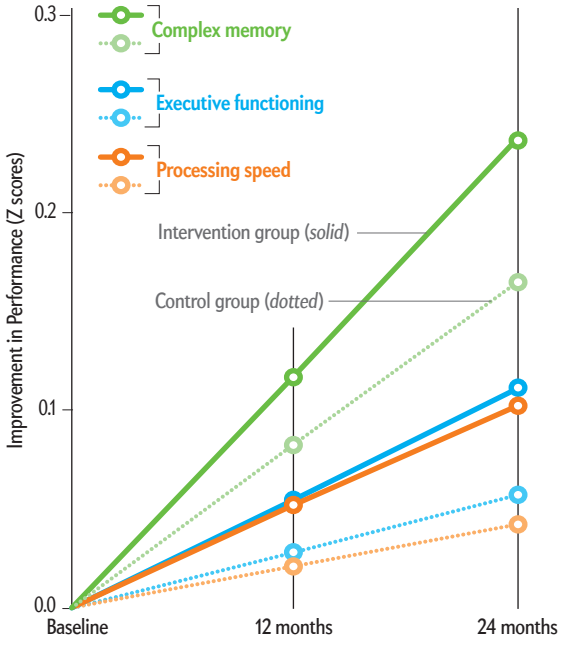
After two years the treatment group showed clear benefits: overall cognitive performance improved on average in both the treatment and control groups, but the intervention group benefited 25 percent more than did controls. Another analysis—looking at the number of people who deteriorated in cognitive performance over the two years—showed a surprising result: the risk of waning cognitive performance turned out to be 30 percent higher in the control group. Improvement in control groups often occurs in randomized controlled trials for various reasons. People usually perform better on the same tests the second time they take them. But FINGER did not have a control group in the traditional sense. The regular meetings with health advice and cardiovascular monitoring attended by participants in the control group became a kind of mini intervention.

Many control subjects may have been inspired by these sessions to make at least some changes to benefit cognitive functioning. Even though we knew that this arrangement might narrow the differences in results between the two groups, we also had an ethical obligation to ensure that the intervention had at least some benefit for the control group. Still, after tallying our results, we did not lose confidence that it represented a real effect, because the treatment group improved by a significantly higher degree than the control group did.

Participants in the treatment group registered significant gains in other areas as well. They improved in specific cognitive

Getting Better

FINGER trial participants in both the treatment and control groups improved on various cognitive measures of memory, executive functioning and mental-processing speed. But the treatment group had better scores after 24 months than the control group did.



SOURCE: "A 2 YEAR MULTIDOMAIN INTERVENTION OF DIET, EXERCISE, COGNITIVE TRAINING, AND VASCULAR RISK MONITORING VERSUS CONTROL TO PREVENT COGNITIVE DECLINE IN AT-RISK ELDERLY PEOPLE (FINGER): A RANDOMISED CONTROLLED TRIAL," BY TIIA NGANDU ET AL., IN *LANCET*, VOL. 385; JUNE 6, 2015

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domains that help people in daily activities that often decline with aging. The intervention group logged an 83 percent improvement over the control group in executive function, a 150 percent better score in speed of processing (time required to perform mental tasks) and a 40 percent performance increase in complex memory tasks (remembering long lists, for instance).

Delving further into our data, we found that participants with a gene variant (*APOE* e4) that puts them at higher risk for Alzheimer's seemed to receive somewhat more benefit from the specified changes than others without it, more proof of the intervention's effectiveness. Those in the treatment group who carried the risk gene had a slower rate of cellular aging, as measured by biological markers called telomeres, caps at the end of a chromosome.

STEPS TO PREVENTION

Physical activity was a key part of the FINGER intervention.

FINGER EXTENSION

WE NOW HAVE FAIRLY GOOD EVIDENCE that a combination of improved diet, physical exercise, mental and social stimulation, and management of cardiovascular problems can improve cognition even after age 60. But we still have more follow-up work to do on our original results.

Finding an improvement in mental functioning after two years implies—but does not prove—that changing one's diet and exercise habits can protect against dementia. To investigate whether it is possible to delay the onset of dementia, we have to consider the long presymptomatic period that is typical of the various forms of dementia. Alzheimer's develops over probably 15 to 20 years before cognitive problems can be diagnosed. We might therefore need to follow people over an extensive period. Of course, it will also be necessary to decide at which point this type of study becomes too expensive and impractical to complete.

Another question we needed to address was whether someone experiencing the brain changes that precede actual cognitive complaints might be helped by counteracting the physiological alterations. Could changes to one's activities of the type implemented in FINGER push back the onset of cognitive issues? Postponing symptoms by two to five years would translate into a significant improvement in public health. Such a delay would mean that many people would probably not receive a dementia diagnosis, because they would die of other causes first.

To investigate some of these questions, we have put in place an extension of FINGER for another seven years. For this next phase, we plan to use brain scans to determine whether good habits might counteract the breakdown in connections among neurons and stem atrophy in certain brain areas, both hallmarks of Alzheimer's. Blood tests may pinpoint whether adopting behaviors that appear to improve cognition lessens inflammation, cellular stress and a deficiency of the proteins that help to ensure brain health—signs of pathology that often turn up in the postmortem brains of Alzheimer's patients.

We are also working with various research teams to bring together findings from studies similar to our own conducted in other countries. The comparisons can help determine whether our discoveries generalize to different populations—combining results can also increase the statistical power of the research and enable more detailed analyses of timely interventions. We could, for instance, compare the levels of physical training among intervention groups from the various studies to identify optimal levels to preserve brain health.

What we have learned from FINGER can also serve as a model for similar studies that attempt to mine the epidemiology literature to extrapolate multiple risk factors that can then be examined in a randomized controlled trial. We are now collaborating on two such projects: the European Union's Healthy Aging through Internet Counseling in the Elderly and the Multimodal Strategies to Promote a Healthy Brain in Aging.

It will not be necessary to wait another decade for health care professionals to start making recommendations to their patients. Already FINGER has provided enough evidence to start suggesting that patients take up the health measures we investigated. And FINGER is now used as a global model for new prevention trials. If the NIH decides to convene a new conference, it might now come to a more optimistic conclusion than the one held seven years ago that was unable to endorse any preventive steps.

The agency might also take assurances from recent reports indicating a decreasing rate of Alzheimer's in the U.S. and for all forms of dementia in both the U.S. and several European countries. This decline may stem from behavioral changes people have implemented on their own after hearing about scientific studies on such changes that can benefit cognitive health.

In the face of a multitude of drug failures, prevention may prove the best way to manage the dementia epidemic, as it has for many other chronic diseases. The take-home message from FINGER is that it may never be too early to take measures to prevent Alzheimer's—and fortunately, it may never be too late, either: changes to the way one lives seem to help some people even after cognitive decline has already begun. SA

Miia Kivipelto is a professor of clinical geriatrics at Sweden's Karolinska Institute. She heads "Theme Aging" at Karolinska University Hospital, an initiative to develop specialized health care for the elderly. Kivipelto is also research director in neuroepidemiology at the University of Eastern Finland.

Krister Håkansson is a researcher in the department of neurobiology, care sciences and society at the Karolinska Institute and a psychology lecturer at Linnaeus University in Sweden.

MORE TO EXPLORE

A 2 Year Multidomain Intervention of Diet, Exercise, Cognitive Training, and Vascular Risk Monitoring versus Control to Prevent Cognitive Decline in At-Risk Elderly People (FINGER): A Randomised Controlled Trial. Tiia Ngandu et al. in *Lancet,* Vol. 385, pages 2255–2263; June 6, 2015.

Defeating Alzheimer's Disease and Other Dementias: A Priority for European Science and Society. Bengt Winblad et al. in *Lancet Neurology,* Vol. 15, No. 5, pages 455–532; April 2016.

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COURTESY OF FINNISH GERIATRIC INTERVENTION STUDY TO PREVENT COGNITIVE IMPAIRMENT AND DISABILITY

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END NOTE

A Smart Schedule for Contentment

Trying to be happier backfires, but consistently planning activities you enjoy may work

By Tori Rodriguez

HAPPINESS JUST CAN'T BE FORCED. Studies have shown that trying to feel happier in a given moment backfires and can actually make people feel worse. And simply paying attention to one's level of happiness tends to make the glass look half-empty. So how can you gain the many rewards of happiness–which include better health and stronger relationships–without forcing it? Recent findings suggest rather than striving to boost happiness in the moment, a more effective route is to maximize your odds by making a concerted effort to plan your time around activities you think you will enjoy.

In a study reported at the end of 2014 in the journal *Emotion,* researchers named this concept "prioritizing positivity" and investigated its association with various measures of well-being in 233 adults who had a wide range of ages. Results show that people who followed this approach were more satisfied with life in general, and they reported more frequent positive emotions and fewer depressive symptoms. Those who prioritized positivity with concrete plans and activities also had more psychological and social resources, such as resilience, mindfulness and positive relationships.

"Reflect on the activities that bring you contentment or joy and make time for these events in your daily life," says study co-author Lahnna I. Catalino, now a professor at Scripps College. "For some people, this could mean regularly setting aside time for gardening and cooking; for others, it could mean making time to connect with good friends." These kinds of efforts can be difficult for those battling depression, but they are in line with what therapists often advise. Of course, you cannot will yourself into a state of happiness, but you can be fairly certain you will enjoy more days that include the things that bring you pleasure. SA

EIKO OJALA

Tori Rodriguez is a journalist and psychotherapist based in Atlanta. Her writing has also appeared in the *Atlantic, Women's Health* and *Real Simple*.

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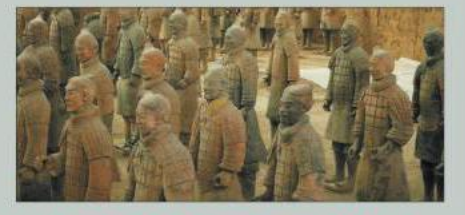

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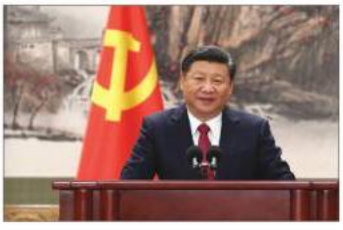
SPEAKER: Ron Martin, Ph.D.



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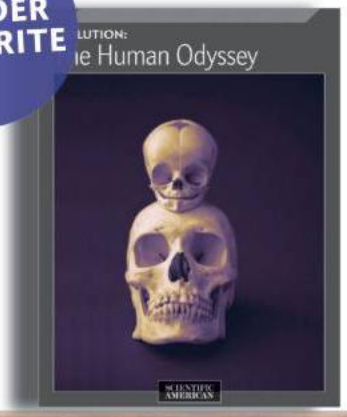

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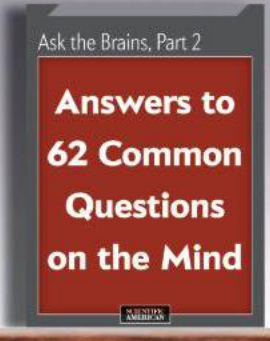

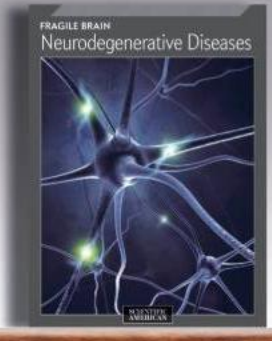

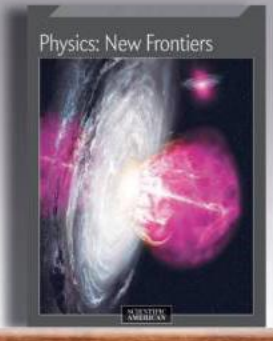

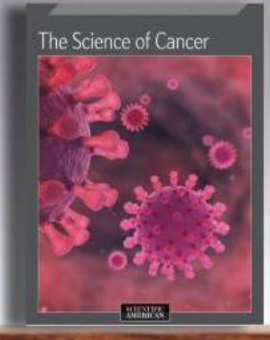

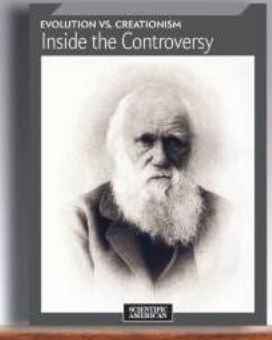

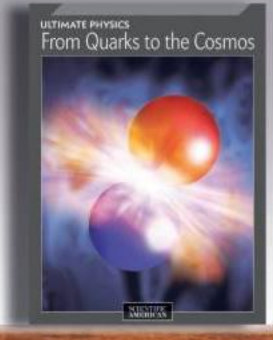

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